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OF THE

NATIONAL FIRE PROTECTION ASSOCIATION

"To Promote the Science and Improve the Methods of Fire Protection and Prevention."

PUBLISHED QUARTERLY AT BOSTON, MASS., BY THE
NATIONAL FIRE PROTECTION ASSOCIATION

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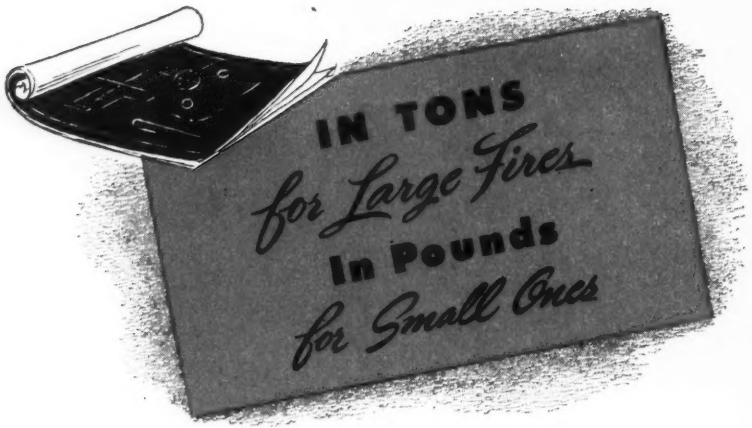

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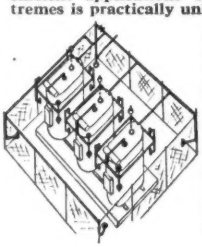

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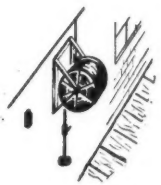

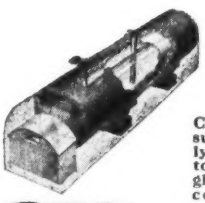

Cardox CO_2 is supplied instantly in pounds or tons from a single Storage Unit containing 500 pounds to 125 tons at controlled low temperature of 0° F. and 300 p. s. i.

Vol. 38 July, 1944 No. 1

QUARTERLY

OF THE

National Fire Protection Association

Subscriptions to the QUARTERLY are accepted only as a part of the general publications of the Association which are sent to members. Associate membership is open to anyone interested; annual dues $10, of which $5 is for subscription to the QUARTERLY.

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National Fire Protection Association

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A NON-PROFIT TECHNICAL AND EDUCATIONAL ORGANIZATION

To promote the science and improve the methods of fire protection and prevention.

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Nine thousand Associate Members.

Executive Office, 60 Batterymarch Street, Boston 10, Mass., U. S. A.

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Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

Manual fire fighting, no matter how many men and how much equipment may be available, can never be an adequate substitute for standard automatic fire protection in large area buildings of combustible construction and with combustible contents. This fire in a U. S. government warehouse in San Francisco, April 5, 1944, caused a loss of $375,000.

The Quarterly

Vol. 38 July, 1944 No. 1

The Next Holocaust? Here is a short but tragic list of fires involving heavy loss of life.

	Lives Lost
May, 1929, Cleveland Hospital.....	125
April, 1930, Columbus Penitentiary.	320
Sept., 1934, *S.S. Morro Castle*.....	125
March, 1937, New London, Texas, School	294
April, 1940, Natchez Dance Hall...	207
Nov., 1942, Boston Night Club....	492
July, 1944, Hartford Circus.....	163

Each of these disasters, with the possible exception of the dance hall fire, brought a wave of public concern and official inspection and legislative action to prevent similar disasters in similar occupancies. Nitrocellulose X-ray film was largely removed from hospitals after the Cleveland Clinic fire. The N.F.P.A. was asked to make a fire survey of all federal prisons *after* the Columbus fire. Congress passed Safety at Sea legislation *after* the *Morro Castle* fire. The importance of safety in schools was realized *after* the Collingwood, Ohio, school fire of 1908, in which 175 lives were lost, and the New London, Texas, fire again called public attention to school fire safety. The Boston Night Club fire caused a clean-up of night clubs everywhere *after* the horrible tragedy had occurred. Now states and cities are busy with plans for circus safety.

The real lesson of all these disasters has somehow failed to reach the public consciousness and that is that fire and panic may take its toll of lives in any place where numbers of people congregate. The principles of life safety such as those set down in the N.F.P.A. Building Exits Code must be made to apply to all places of public assembly if we are to stop wholesale deaths by fire. Why wait for a huge loss of life to occur in the bargain basement of a big department store during the Christmas buying rush before doing anything to see that all such areas meet at least reasonable fire and exit standards? Shall we wait for a church fire and panic taking a toll of lives before we think about the protection of people in churches? Shall we wait for people to die in the assembly room or banquet hall on the top floor of some hotel before we make sure that such places are free from fire and panic possibilities?

Locked exits, obstructed exits, inadequate exits, lack of automatic sprinklers where obviously necessary, flammable decorations and hangings, loose seats, needless accumulations of flammable goods or materials, promiscuous smoking in hazardous areas, and other obvious factors can all be taken care of in all places where large numbers of people congregate before and not after fire strikes. An aroused and intelligent public opinion is what is needed to see that all such places are really made safe for the men, women and children that flock to them, trusting to someone else to have made sure that at least they have a reasonable chance to get out alive if an outbreak of fire occurs.

Meetings of Board of Directors.

Philadelphia, May 8, 1944.

Present.

George W. Elliott, Chairman
David J. Price, President
Richard E. Vernor, Vice-President
C. C. Johnson, Vice-President
Alvah Small, Past President
Hovey T. Freeman, Secretary-Treasurer

A. L. Brown	H. E. Newell
Frank Epps	C. W. Pierce
Russell Grinnell	L. G. Schraffenberger
W. F. Hickey	A. H. S. Stead
Harold L. Miner	Lloyd T. Wheeler

John L. Wilds

Percy Bugbee, General Manager; Robert S. Moulton, Technical Secretary; Horatio Bond, Chief Engineer.

Business Transacted.

1. The report of the Chairman of the Board to the annual meeting was approved.

2. The report of the Treasurer was approved for presentation at the annual meeting.

3. The report of the Committee on Technical Committee Procedure was adopted, including action on the following items:

(a) Creation of the Committee on Aircraft Fire Fighting was confirmed, with Colonel Harrison G. Reynolds of the Army Air Corps as Chairman.

(b) Mr. R. C. Stange of the National Board of Fire Underwriters, now serving as Fire Protection Consultant to the U. S. Coast Guard, was appointed as Chairman of the Committee on Piers and Wharves to fill the vacancy caused by the death of the former Chairman, Mr. C. H. Fischer.

(c) A new Committee on General Storage was created to deal with warehousing and storage practices for materials and commodities not now covered by other N.F.P.A. committees. Mr. E. J. Hogan, Chief of the Storage Branch, Division of Stockpiling and Transportation, War Production Board, was appointed Chairman of this committee and the Committee on Technical Committee Procedure was authorized to complete the personnel subject to confirmation by the Board at a subsequent meeting.

4. A proposal for the establishment of a system of awards for meritorious service in fire protection was considered and referred to the Advisory Committee for report to the Board at the next meeting.

5. It was voted to recommend to the annual meeting that Past President Alvah Small be elected an Honorary Member.

6. Board Member H. E. Newell was appointed to the Committee on Technical Committee Procedure to take the place of the late member S. D. McComb.

7. It was voted to hold the next meeting of the Board in Philadelphia on June 29.

Philadelphia, Pa., June 29, 1944.

Present.

George W. Elliott, Chairman
Richard E. Vernor, President
C. C. Johnson, Vice-President
Alvah Small, Past President
Hovey T. Freeman, Secretary-Treasurer

Eugene Arms	H. L. Miner
A. L. Brown	H. E. Newell
Frank Epps	C. W. Pierce
Russell Grinnell	H. E. C. Rainey
W. F. Hickey	L. G. Schraffenberger

John L. Wilds

Percy Bugbee, General Manager; Robert S. Moulton, Technical Secretary; Horatio Bond, Chief Engineer.

Business Transacted.

1. In accordance with the recommendations of the annual meeting, the following officers of the Corporation were elected for the year 1944-1945: President, Richard E. Vernor; Vice-President, E. O. Shreve; Vice-President, C. C. Johnson; Secretary-Treasurer, Hovey T. Freeman; Chairman, Board of Directors, George W. Elliott.

2. The Advisory Committee for 1944-1945 was appointed as follows: George W. Elliott, Chairman; E. O. Shreve, Richard E. Vernor, C. C. Johnson, Hovey T. Freeman, C. W. Pierce.

3. Messrs. H. E. Newell and A. H. S. Stead were selected to complete the Nominating Committee for 1945.

4. It was voted to hold the 49th annual meeting in Chicago, May 7-10, 1945, subject to possible change at the January meeting of the Board in case of unforeseen developments.

5. The Program Committee for the 1945 annual meeting was appointed as follows: the President, Chairman of the Board of Directors and the General Manager.

6. The budget for 1944-45 as recommended by the Finance Committee was approved.

7. Proposed regulations for the operation of N.F.P.A. sections submitted by the Advisory Committee in accordance with the action of the Board at its last meeting were approved for submission to the next annual meeting of the Association. The proposed regulations as revised by the Board are as follows:

1. Subject to approval of the Board of Directors of the N.F.P.A., groups of members having specialized interest in fire protection may be organized in sections or existing separate organizations may be constituted as sections of the National Fire Protection Association by action of the Board of Directors. The qualifications for membership in every section shall be specifically defined. Groups or organizations desiring to become sections shall submit their proposals to the Board for action.

2. Membership of sections shall be confined to associate members of the N.F.P.A. and representatives of organization members.

3. Sections may elect their own officers and formulate their own by-laws and procedures, provided that their organization by-laws and procedures must be consistent with the Articles of Association and Regulations for Committee Procedure of the Association.

4. Sections may hold meetings for discussion, interchange of information, and promotion of the objectives of their membership and otherwise operate as they may desire consistent with the general policies of the Association. Sections may propose or recommend to the annual meeting or to the Board of Directors action on any matter desired. Meetings of sections may be held at such time and place as the section may desire, provided that one meeting each year shall be held at the time and place of the Association annual meeting unless omitted by consent of the annual meeting Program Committee on request of the section.

5. Section meetings shall be open to all members of the Association except that sections may hold closed sessions with attendance limited to members of the section, N.F.P.A. officers and Directors, and staff representatives.

6. Sections may propose standards, model laws and ordinances, or propose other action committing the Association only in conformity with the established procedure of the Association.

7. Sections shall not solicit funds or accept contributions except when authorized by the Association in annual meeting or by the Board of Directors.

8. Sections shall not incur financial obligations or commit themselves or the Association to any expenditures unless previously authorized by the Finance Committee or the Board of Directors.

9. The N.F.P.A. Executive Office staff shall provide service for sections in accordance with authorization by the Board of Directors.

10. Sections may be represented on technical committees of the Association in accordance with the Regulations on Technical Committee Procedure.

11. The Board of Directors after due notice and hearing may suspend or terminate any section which does not conform to these regulations or whose members do not show sufficient interest to justify continuance of the section organization.

8. A proposal for the establishment of a program of awards for meritorious service in fire protection was considered without action.

9. The establishment of a pension plan for N.F.P.A. Executive Office employees was discussed. The General Manager was requested to consider the matter further in conference with the Finance Committee and to report to the Board at such time as it may be possible to devise a satisfactory pension plan.

10. The resignation of Dr. David J. Price as Chairman of the Committee on Long Range Planning was accepted with a vote of appreciation to Dr. Price for his service as Chairman of this committee.

11. Reports on war activities and policies were made by Messrs. Bugbee, Moulton and Bond of the N.F.P.A. staff. It was voted to approve these reports with commendation to the staff and to authorize the continuance of these activities.

12. Mr. Alvah Small, representative of the Fire Protection Group on the A.S.A. Board of Directors, reported on current developments in the American Standards Association. It was voted to authorize Mr. Small to use his best judgment in voting on proposed changes in the A.S.A. constitution.

13. The hazard of flammable products marketed under trade names long used to denote non-flammable products was discussed, with the suggestion to the N.F.P.A. office that members be advised to examine labels on containers and to report to the appropriate authorities any observed cases of improper labeling.

14. The report of the Committee on Technical Committee Procedure was approved, including action on the following items:

(a) The committee was authorized to proceed with appointments to the technical committees of the Association prior to the printing of the 1944 Year Book, subject to confirmation by the Board at its next meeting.

(b) The Executive Office was authorized on receipt of an official communication from the American Standards Association to accept joint sponsorship for the Code on Lightning Protection, the other joint sponsors being the American Institute of Electrical Engineers and the National Bureau of Standards, the acceptance of this sponsorship to be limited to Parts 1, 2 and 3 of the Lightning Code, eliminating Part 4 dealing with the Protection of Power and Railroad Circuits and Equipment and Part 5 Protection of Communication and Signaling Circuits and Equipment. The Committee on Technical Committee Procedure was authorized to act for the Board in the reorganization of the committee and its consolidation with the existing N.F.P.A. Committee on Protection Against Lightning.

15. On recommendation by the Committee on Fire Pumps in accordance with the authorization of the 1944 annual meeting, the following additional amendments to the Standards for the Installation and Operation of Centrifugal Fire Pumps were adopted:

401 (c). Revise to read: "The engine shall develop at least 10 per cent greater power than is required to operate the pump at rated speed under any conditions of pump load."

401 (d). Omit this paragraph, relettering remaining paragraphs.

401 (g). Revise to read: "A governor shall be provided for the engine to regulate the speed within a range of 10 per cent between shut off and maximum load conditions of the pump. It shall be set to maintain rated speed at rated load."

401 (1). Insert the words, "using heavy duty Diesel type batteries," after the word "equipped" in the second sentence.

402 (a). Add the following sentence: "Ventilation should be adequate for engine air supply and for removal of hazardous vapors."

Chairman H. E. Newell of the Committee on Gases reported progress on the committee consideration of changes in the Standards on Hospital Operating Rooms referred to the committee with power to report to the Board by action of the 1944 annual meeting. The Executive Office was requested to submit these proposed changes to members of the Board for letter ballot on completion of action by the Committee on Gases.

16. Committee appointments recommended by the Committee on Technical Committee Procedure and by the officers were confirmed. The existing members of all technical committees, except for vacancies due to deaths and retirements, were reappointed for the year 1944-45 (the revised committee lists will appear in the 1944 Year Book to be published as Part II of the October, 1944, QUARTERLY).

Hartford Circus Holocaust.

By Warren Y. Kimball,
N.F.P.A. Engineer.

Danger from fire was far from the minds of some 7000 happy patrons attending "the greatest show on earth" at the city-owned circus grounds on the outskirts of Hartford, Connecticut, on the hot sunny afternoon of July 6, 1944. About twenty minutes after the matinee started a "flash fire" occurred which caused fatal injuries to 163 persons, mostly women and children. Sixty-three of the dead were children under 15 years of age. Well over 200 other patrons were confined to hospitals as a result of burns and some 50 or 60 circus employees were treated by their own physician. Some of the critically injured patrons may yet succumb.

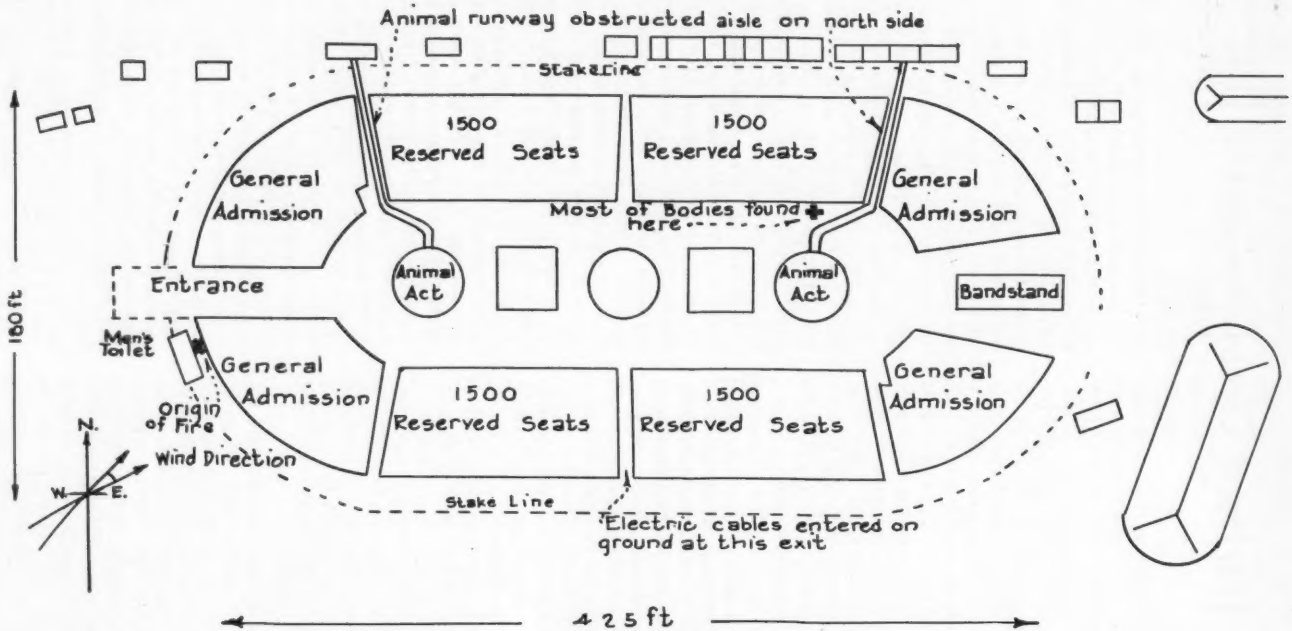
Hartford, Connecticut, the "Insurance Capital" has for years carried the proud boast of "best governed city in America." Just a few weeks prior to the fire the city won the grand award in the Inter-Chamber Fire Waste Contest. This was in a large measure due to the outstanding work of the Fire Prevention Bureau under City Fire Marshal Henry G. Thomas. As an overcrowded war industry center probably no city had been more aggressive in carrying out fire safety measures, such as the installation of adequate exits from various types of lodgings and places of public assembly. It is said that War Production Board officials had recently complained that Hartford was using up more critical iron in providing fire escapes than any other city, but when shown the need by the Fire Prevention Bureau the necessary priorities were granted.

The Ringling Brothers and Barnum and Bailey Combined Shows had carried on their great show in many states and for many years with conditions substantially the same as those which resulted in the Hartford tragedy. The seating arrangements, the performances, the arrangement of the "big top" were all "routine." The circus had visited a number of other New England cities in the weeks prior to the fire. It had visited Hartford in previous years. The set-up had been the same and local officials in every case had welcomed the circus without questioning. The circus was an institution older than the building codes of most cities and much older than the comparatively new development of municipal fire prevention bureaus. City officials everywhere enjoyed the circus. It brought them their youth again for an afternoon. They had no doubt welcomed the circus as small boys and helped "water the elephants." The circus was an old friend.

The circus was pitched on a city-owned circus lot. It was late in arriving and there was some haste in getting ready for the afternoon show. A city Building Department inspector was on the scene before the stands were up and issued a permit. Apparently this was considered routine and it was stated the inspection was made to cover zoning ordinance requirements. There is no indication that the inspector gave any consideration to such matters as width of exits or flameproofing of the canvas. The Fire Prevention Bureau of the Fire Department received no notice from the Building Department regarding the issuance of the permit and had no official notification that the circus was in operation. Neither did the Fire Department, under Chief John C. King, have a fire fighting detail at the circus until after the tragedy, although the Police Department did have a detail at the scene.

Preparations for fire safety at the circus would appear to have been somewhat meagre considering the magnitude of the crowds handled and the fire hazards which obviously were present. The circus equipment included four all-purpose water tank trucks having pumps powered by a power take-off and supplying 50 feet of 2-inch hose having a ½-inch nozzle tip. These pumps produced a nozzle pressure of approximately 58 pounds, which would give a discharge of about 56 gallons per min-

This report, while necessarily of a preliminary nature due to the fact that official investigations have not been completed, is believed to include the essential facts responsible for this great tragedy. We are indebted to N.F.P.A. members in Hartford who have made it possible for us to inspect the circus site and have given us extensive help in obtaining pertinent details regarding this fire.



APPROXIMATE PLAN OF CIRCUS.

This plan, drawn after an examination of the ruins, shows the approximate arrangements, but may not be accurate in all details. The small squares beyond the side of the tent were animal cage wagons. Many other circus wagons in front of the main entrance and elsewhere on the grounds are not shown on this plan. At the right were performers' tents not involved in the fire.

ute. Three of the tank trucks had a capacity of 1000 gallons each and the other had 800 gallons capacity. During each performance there were two circus hands detailed to each truck and these were in operation during the fire, but the circus employed no professional firemen and had no fire marshal or fire chief on its staff. There is evidence that the circus equipment may have been of some use in extinguishing fire in the blazing stands near the point of origin, but it was obviously inconsequential as a means of preventing the loss of life. The only other private fire fighting equipment that was available for quick use were water buckets. A number of fire extinguishers carried by circus vehicles were not distributed about the tent for protection of the show.

The Connecticut State Police Commissioner, Col. Edward J. Hickey, who is ex-officio State Fire Marshal, was entertaining a party of children at the circus on the afternoon of the tragedy. He is conducting the official investigation of the tragedy, with a personal determination that such a fire shall never occur again in the State of Connecticut.

Description of the Tent.

The huge tent where the fire occurred was approximately 425 feet long and 180 feet wide and covering an area of approximately 74,000 square feet or better than 1½ acres. It was the usual type of large circus tent supported by a large number of heavy poles held by guy ropes secured to a double row of stakes approximately 15 feet outside the tent. The largest poles had a maximum diameter of 12 inches. The outer circumference of the tent contained a tier of stands having a seating capacity of 9048 persons. This was distributed between 6048 reserved seats, running along the north and south sides of the tent and 3000 general admission seats located at the two ends of the tent. During the afternoon performance when the fire occurred there were 6789 paid admissions, indicating that some 7000 patrons were in the tent. There is no indication of the number of performers or employees actually in the tent at the time of the fire, but the circus had a staff of over 1300 persons, as compared to a normal peace time complement of about 1600 employees.

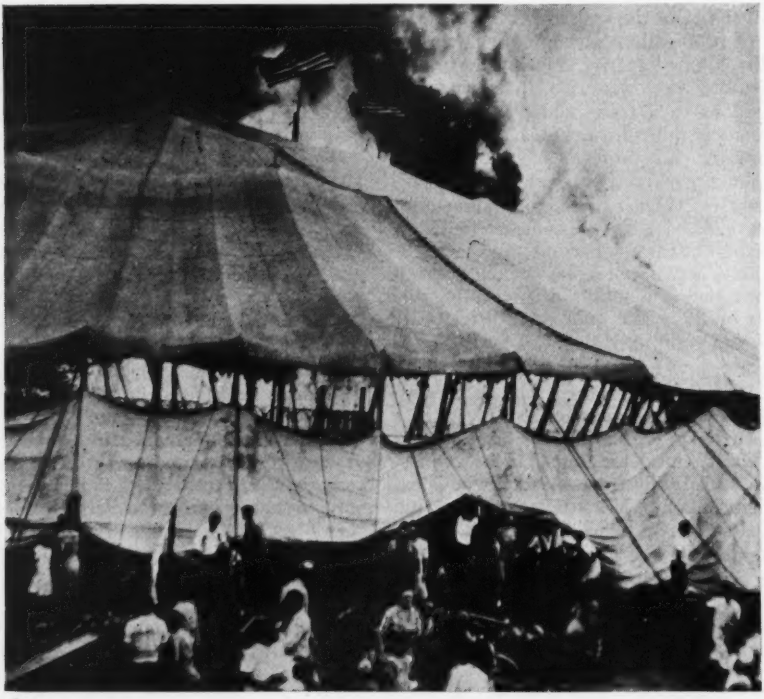
Running along the center axis of the tent and separated from the spectators by the wide aisle by which the patrons reached their seats, were three show rings. Between the show rings were two square platforms used for additional acts.

The seating stands were reported to be 10½ feet maximum height at the rear of each stand and there were 16 to 18 rows of seats, depending upon the type of accommodation.

At the time of the fire wild animal acts had just been completed in the rings at the east and west ends of the tent. Temporary steel cages were erected in these rings for the animal acts. Animals were brought into these rings through long temporary cage runways, called "chutes" in circus parlance. These extended to animal conveyance trucks located north of the main tent. It was one of these animal cage runways extending across the main north aisle that blocked the escape of many of the spectators as they fled in an easterly direction away from the fire. These animal chute cages appeared to vary in height from about three to four feet. They were two to three feet wide.

Exit Arrangements.

It is understood that the Hartford Building Department records indicated nine means of exit from the tent. This was confirmed by N.F.P.A. staff investigation at the scene of the fire. The main entrance at the west end was a little over 20 feet wide on the inside of the stands and widened out to something over 30 feet at the point of egress, which was under an entrance canopy. At the opposite or east end was located the bandstand with an exit on each side of the stand. These exits were better than 14 feet wide at the narrowest point and widened to nearly 19 feet at the point of egress. These were the only really commodious exits from the circus tent. On both the north and south sides there were three minor exits used primarily by performers, but available to the public. These exits averaged 9 or 10 feet wide at the ringside, but narrowed down to as little as 5 feet 2 inches at the point of egress. The center of these exits on the south side was used to bring electric cables along the ground into the tent. At the time of the fire the east and west exits on the north side were occupied by the animal chutes,



Acme.

Many people jumped off the back of the stands, or crawled down between the seats and escaped under the canvas side walls. Perhaps this possibility has been the excuse for grossly inadequate exits in circuses, but this fire shows the fallacy of relying on anything but standard exits.

leaving unobstructed only a single exit having an egress width of 5 feet 2 inches to serve two sections of grandstand each approximately 125 feet long and having approximately 3000 total seating capacity. The runway chute cages that obstructed the main north aisle and two of the exits on the north side were bridged by a stile five feet wide and five steps high. These stiles proved utterly inadequate to handle the panic-stricken crowd.

Adequacy of Exits.

As is well known to most N.F.P.A. members, the Building Exits Code of the National Fire Protection Association has for many years been the life safety standard for the protection of public gatherings and other crowded occupancies against fire and panic hazards. The Building Exits Code was prepared by the N.F.P.A. Committee on Safety to Life, a representative group of experts in this field. While many persons may not have thought of applying the Code to anything as unsubstantial as a tent, this fire is evidence that adequate exits are needed for tents and other temporary structures serving large crowds.

The Building Exits Code requires one 22-inch unit of exit for each 100 persons accommodated. On this basis the circus would have required 91 units of exit width, whereas our study of the circus grounds after the fire showed a maximum of 43 units of exit width actually provided. At the time of the fire these limited exit facilities were further reduced by the obstruction of two of the north exits by the animal chute cages. The effect of this was to block off two sections of reserved seats, having approximately 3000 seating capacity, and leaving only one narrow exit which was less than three 22-inch units in width,

and thus could not be expected to take care of more than 10 per cent of the persons isolated in the northern grandstands. Incidentally, it should be pointed out that the N.F.P.A. Building Exits Code requirements are considered to be quite lenient because they are designed for more substantial structures than tents and many cities might wish to have more stringent requirements in the case of temporary structures or tents.

Acme.

Site of the main entrance. A section of one of the animal chutes in the foreground.

One factor that should not be overlooked in any appraisal of exit facilities at the circus was that the main exit aisle in front of the stands, some 26 to 27 feet wide at the narrowest point, was not available to the audience during much of the performance. Not only was this main track blocked temporarily by the animal chutes, but it is in use by the performers through much of the show. The grand parade circles the track, it is used by the parade of elephants, by chariot races, wild west riders and numerous other attractions. In short, except at the beginning and end of the show the spectators are largely kept behind the metal railing that circles the arena. There is room behind this railing for the movement of only a very narrow file of persons in the limited space in front of the stands. This situation conflicts with Building Exit Code requirements that exits be unobstructed at all times. Likewise the fact that several of the exits were much smaller at the point of egress than was indicated by their dimension at the ringside is also a further conflict with good exit arrangement.

Story of the Fire.

The fire began on or near the ground at the outside canvas immediately to the south of and about 20 feet from the main exit. The point where the fire started was between the outside canvas of the main tent and the canvas enclosure for the men's toilet which backed up to the main tent at that point. The grass is said to have been dry from the heat and dust common to circus grounds, and might easily have been ignited by a match or cigarette. However, some grass within a few feet of the fire area did not appear to be burned, although trees 50 to 60 feet from the fire showed scorched foliage.

When first noticed, the flame was 5 or 6 feet high. Although standard fire extinguishers or a small hose line immediately applied might have conceivably controlled a fire of this size without difficulty, it had already spread enough to make 3 buckets of water thrown on it ineffective.

As the fire rapidly increased and hit the edge of the top canvas, the flame was about 2 feet wide at the point of contact. A gust of wind from the southwest then drove the fire across the underside of the tent and almost instantly the entire canvas was enveloped in flames. The ropes holding the supporting poles were burned through almost at once, allowing the great poles to fall among the panic-stricken throng and causing several fatalities.

It is reported by several spectators that the majority of the crowd did not leave immediately at the first sign of fire. Several persons seated near the point of origin are said to have walked the entire length of the tent to the further exit before the panic occurred. It is said that at the outset the crowd viewed the fire incredulously, thought it part of the show, or believed it to be an incipient fire that would quickly be controlled, The delay, if only momentary, may have been fatal to some of those who a few seconds later were in the panic-stricken mob seeking to escape.

As previously pointed out, the animal runway chutes temporarily blocked the best means of exit for most of the seats on the north side of the tent. As the people ran down the aisle toward the eastern end of the tent to escape the flames they piled

Acme.

The burning of the circus tent in Hartford, July 6, 1944, where 163 people were killed, mostly women and children, and some 200 injured. The flames flashed over the paraffin treated canvas with incredible rapidity.

up against the animal runway at that end. The steps over these runways proved utterly inadequate. Attempts to climb over the steel cage bars were largely futile for women in high heeled shoes and for small children. Most of the bodies of those who failed to reach the outside were found piled four deep against this cage obstruction in the main north aisle.

Another cause of confusion and injury was the excessive use of loose folding chairs in substantial portions of the reserved seat section. This was contrary to provisions of the N.F.P.A. Building Exits Code which specifies that where more than 200 seats are provided they shall be securely fastened to the floor. As the people dashed out, they shoved the loose chairs down the tiers ahead of them. Those in the middle tiers stumbled and fell across the piles of loose chairs blocking their escape. Persons in the first five or six rows got out more easily. Those in the back jumped the 10 or 12 feet to the ground to escape under the canvas.

Most of the fatalities were due to severe burns as the blazing canvas fell on the crowd, igniting flimsy summer clothing. This is in contrast to the Cocoanut Grove fire in Boston where many of the deaths were by suffocation. It is probable that some of the deaths were due to crushing by the panic-stricken mob, even though burns quickly followed. The fire appeared to be quite spotty in character, as some seats and poles showed unburned paint, while adjacent areas were deeply charred and some of the wooden stands, particularly on the south side, were almost completely consumed.

Fire Fighting Operations.

Once the fire started it was obviously impossible for fire fighters to reach the scene in time to prevent a tragedy. As a matter of fact, had the entire fire department been stationed at the circus grounds there is little likelihood that the outcome would have been any different once the top canvas became ignited.

Calls to the fire department were given promptly by an off-duty fireman attending the circus, a police radio car, and a resident of a near-by house. Three box alarms were sounded almost simultaneously. These calls brought an immediate response of seven engine and three ladder companies. The nearest fire company was approximately one-half mile from the tent.

The nearest hydrant was approximately 300 feet from the front entrance of the tent. Other hydrants were spaced about 500 feet apart along the street leading to the circus grounds and on adjacent streets. Some six hydrants were used. There were no fire hydrants in the circus grounds.

Fire Marshal Thomas, who is also First Deputy Chief of the Hartford Fire Department, was the first chief officer on the scene. He reported that within ten minutes from the start of the fire the canvas was completely consumed, the poles were down and the fire fighters' chief task was to extinguish the blazing stands and extricate the dead. Examination of the ruins indicates that the fire department devoted its first attention to extinguishing the fire in the area where the people were trapped, in an effort to save all possible lives.

Cause of the Fire.

As soon as the fire was under control, Mayor Mortensen of Hartford authorized the Fire Marshal to conduct an investigation of the fire. This was started immediately and continued at the circus ground until 11 P.M., when the investigation was transferred to the State Fire Marshal's office. Newspapers have reported that the cause of the fire has been determined, but this information as well as many other technical details is being held for presentation to the State's Attorney. However, the point of origin is definitely known and the fire is generally attributed to careless smoking.

At the point where the fire started the sidewall canvas was supported by a wooden framework. This framework was in the shape of an inverted V of approximately 2 by 4-inch timbers. This was braced by a sill of about 1 by 4-inch board mortised into the uprights at either side. At the left hand side of this inverted V the structural members had been charred through over an area about 5 inches long. This was considered unusual as it showed an intensity of fire much more serious than evidenced at other places close to the point

International.

The grim ruins of the 1½-acre tent. One of the animal chutes leading to the large cage may be seen at the left center. Most of the loss of life occurred in front of the stands at the left.

of origin. It has been observed that the seats nearest where the fire started were the least damaged. It is reasoned that the wooden structural members should have been less flammable than the sidewall canvas which was so quickly consumed, and therefore this portion of the framework should not have been subjected to the intense localized exposure indicated by this evidence of severe heat at the immediate spot where the fire started.

It has also been observed that a match or cigarette could have smouldered for several minutes in the dried grass at the point of origin before the fire extended to the sidewall canvas and attained sufficient headway to attract attention.

It was recalled during the investigation that the same circus had suffered a serious fire of believed incendiary origin when a menagerie tent was destroyed at Cleveland, Ohio, on August 4, 1942. Negro roustabouts had reportedly confessed setting this previous fire after being discharged from employment. However, a number of circus hands questioned after the Hartford fire reportedly expressed the opinion that the Cleveland fire was due to a locomotive spark or some other external cause. Electricity has been ruled out as a possible cause of the Hartford tragedy, as cables entered the tent at a point remote from where this fire started.

However, under normal circumstances the immediate cause of this fire seems immaterial, as the flame once started by any common cause of fire could have had the same results once the highly flammable canvas ignited, irrespective of the source of ignition.

Flameproofing of Canvas.

The practically new canvas of the "big top" had no flameproofing. It had been processed against water by the use of paraffin applied with gasoline as a solvent. This was done late in April. It was said to have been the time-honored method of waterproofing used by the circus. The gasoline solvent undoubtedly had evaporated prior to the date of the fire, although possibly some petroleum residues may have remained with the paraffin waterproofing. It is reported that a circus "big top" had been destroyed in a previous fire in 1912 at Sterling, Illinois, when sparks from an exposure fire ignited the paraffin coated canvas. Fortunately on that occasion the fire occurred shortly before the show and the crowd was refused admittance to the tent. On March 5, 1929, a huge tent housing the Los Angeles Auto Show was destroyed by a fire of unknown origin, which caused $1,500,000 loss. Some 2500 patrons, who represented only a small fraction of the reported capacity of

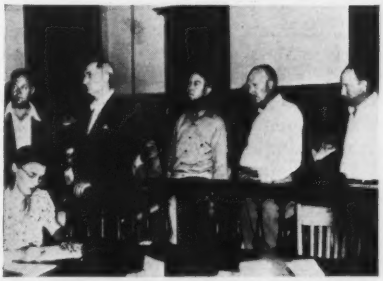
the tent, escaped without fatalities.

It is probable that one aftermath of this fire will be the adoption of ordinances requiring the flameproofing of tents used for various circus shows, and carnivals. While no treatment of combustible material such as canvas can make it actually "fireproof," it is possible to apply flameproofing chemicals so that the canvas not previously treated with wax or paraffin, cannot be ignited by the flame of a match or any similar minor source of ignition. The practical difficulty with most flameproofing treatments has been that the chemicals would dissolve in water and after continued exposure to the weather they would be washed out. This difficulty has been overcome by certain manufacturers of flameproofed canvas who combine effective waterproofing with the flameproofing and produce a product which retains its fire-resistant properties for the normal life of the canvas. It is reported that such treated canvas is used extensively by the Army and Navy; it is also used for awnings, and for tarpaulins to protect railroad shipments.

Such flameproofed canvas is entirely different in its fire behavior from ordinary canvas used for tents. Ordinary canvas is frequently treated with paraffin or some other waterproofing compound which tends to increase its naturally high flammability.* The only practical method of determining the flameproof qualities of canvas is to make a fire test on a sample. This would involve cutting out sections of the tent for a test, necessitating subsequent patching. It is not surprising that fire inspectors have not made such tests on circus tents which are customarily erected only a few hours before they are used for public performances.

Underwriters' Laboratories, Inc., list flameproof fabrics made by two different manufacturers. These fabrics are chemically treated. The product is comparatively difficult to ignite and does not propagate flame, even when in drafts, beyond the area exposed to the source of ignition. Smouldering combustion which occurs on ignition may spread in folds of such fabrics, but does not extend beyond the area exposed to ignition.

*The N.F.P.A. has a standard on the Flameproofing of Textiles.



International.

Five of the circus officials were arrested on warrants for manslaughter.

Damage and Loss.

Estimates of loss to circus property varied from $200,000 to $300,000, including destruction of the main tent said to be valued at $50,000. According to reports the circus was extensively insured against both fire damage and liability, although the full amount of coverage has not yet been reported. The city of Hartford has attached all of the circus property in the city not destroyed by fire, except the menagerie animals (which are hearty eaters) in an effort to prevent removal of values which might be used to meet various claims. It was reported in the press that within a week of the fire papers had been served by individuals asking a total of $497,000 in damages. Later damage claims reached $1,100,000. The city was co-defendant with the circus in most of the actions. Judging from previous fire disasters, life insurance and social security claims in a disaster of this sort may reach a sizable sum, even though women and children, who suffered most of the casualties in the Hartford fire, seldom have as much insurance protection as would be the case with an equal number of men.

Indictments.

Subsequent to the fire, five circus officials have been indicted on manslaughter charges, but all were released on bail amounting to $10,000 to $15,000 each. Hearings on these indictments have been set for July 19. It was not known whether other indictments would be returned.

Corrective Measures.

Col. Edward J. Hickey, Connecticut State Fire Marshal, took prompt action to prevent similar disasters in the future. Another circus visiting the state was compelled to remove the top canvas of its main tent and a detail of 50 firemen stood by with pumpers and charged hose lines during performances.

Likewise, it is reported that Mayor Mortensen plans to appoint a body of distinguished citizens to investigate the operations of the various city departments in relation to the disaster. It seems quite likely that one result will be the strengthening of the fire prevention ordinances along lines previously recommended by the Hartford Fire Prevention Bureau. More adequate staffing of the Fire Prevention Bureau is another urgent need. This important bureau, which is an adjunct of the Fire Department, has been chronically understaffed considering the large volume of inspections, records, and permits it is called upon to handle. The excellent work accomplished by the Bureau under these handicaps is largely due to the energy and devotion of the small fire prevention staff. This is a condition not alone peculiar to Hartford, as Fire Prevention Bureaus throughout the United States have had a marked curtailment as fire departments have felt the pinch of manpower since the start of the war. In a number of cities the fire prevention staff has been completely eliminated and all inspectors have been sent back to active fire fighting.

Conclusions.

Perhaps the most concise summary of lessons from this fire was that published editorially in the *Hartford Times* for July 12, as follows:

"To make sure that such a disaster shall not be repeated the following are absolutely essential:

"1. Maximum fire-resistant treatment of material used for tents housing circuses or other large gatherings of people, plus frequent inspections to assure that the treatment remains effective.

"2. Provision of numerous unobstructed exits from all parts of the enclosure, regardless of how much such exits may reduce seating capacity of the grandstands.

"3. Restriction, even prohibition of smoking. Already smoking is forbidden in crowded stores; it is much more necessary to forbid it in all places where large crowds gather for amusements."

There can be little doubt that like all great disasters, such as major fires and conflagrations, a combination of unfavorable circumstances was present to formulate a disaster. The circus had played thousands of performances under substantially similar arrangements without difficulty. It just happened that at Hartford the canvas was ignited supposedly from an accidental fire at a spot close to the main entrance at a time when the wind from the southwest was in a position to push it through the tent, and at a time when the exits for the north side of the tent were seriously obstructed.

It is, however, felt that under other circumstances the disaster might have been much worse. A few minutes prior to the start of the fire the main exit aisle was occupied by the parade of more than thirty elephants. Had the blaze occurred at that time and sent the giant beasts terror-stricken among the audience the toll could have been greater. Likewise, had the fire occurred at night and the crowd been forced to flee from the tent through the maze of tent pegs and ropes into the night the loss of life might have been many times greater despite the use of numerous floodlights on the grounds.

Proper exit facilities unobstructed at all times during the performance and flameproofing of the tent canvas would have prevented this loss of life from fire and panic, although it is doubtful that a tent can ever be considered as safe for large audiences as a well-constructed exhibition building. Severe lightning and windstorms, and the danger of escaping wild animals, present a danger of panic conditions, particularly now that the public is aware of the heretofore unappreciated dangers of a circus performance.

Treatment of the Injured.

The following article, reprinted from the *Hartford Times* of July 12, gives an account of the way in which the more than 200 seriously burned circus patrons received medical aid.

Preparations for War and Cocoanut Grove Experience Prove Boon to Scores of Injured in Circus Tragedy Here.

Many of the badly burned casualties of Hartford's circus catastrophe will owe their lives to the grim tragedy of war, and to the disastrous fire in Boston's Cocoanut Grove.

Patients streaming into the Municipal Hospital Thursday afternoon, with 25 to 75 per cent of their body surface severely burned, could not have been cared for before the war. Plasma, the all-important life-saver, would not have been on hand in adequate amounts, nor would it even have been available, for the public has only recently become educated to the necessity of blood donation. Without plasma the mortality rate would have been increased 50 to 60 per cent, perhaps even 90 per cent, doctors on the scene say. One of the greatest lessons learned from war experience and from the Boston fire was the absolute necessity for speed, for the generous use of plasma, and for oxygen.

When the first call for ambulances came in to the Municipal Hospital from the Police Department, no one could guess at the extent of the fire, nor foresee the great number of severely injured. In preparation for any exigency, however, every department of the hospital was immediately mobilized. Each floor was directed to send the maximum number of nurses which could be spared to the admitting room; doctors and nurses off duty were called back; extra nurses and internes were requested from Hartford and St. Francis Hospitals, and transported almost immediately to the Municipal Hospital by the Red Cross Motor Corps.

As the staff doctors, internes and nurses on duty brought supplies of morphine and plasma and other necessary equipment to the admitting rooms, calls were still going out from the hospital office to the Red Cross for help from its volunteer services, to the Hartford War Council, to the list of the visiting staff of doctors.

Within five to ten minutes after the first call came in, the hospital roads and grounds were swarming with every available ambulance from Hartford and vicinity. Two staff doctors, each with two nurses as assistants, met the casualties at the door, made a quick estimate of the extent of the burns of each, considering body surface injured and intensity of the burns, prescribed immediate care and directed distribution of the patients.

Ambulatory cases were sidetracked to the out-patient clinic rooms, treated on the spot, and sent home. All those needing hospitalization were given morphine immediately during the initial examination, their clothes were cut off, they were wrapped in sterile sheets, and the injection of plasma was started as soon as possible.

International.

The Morgue. Three days after the fire 32 bodies were still unidentified.

While the mobilization of hospital facilities was getting under way, scores of doctors from all parts of the city and state were streaming into the hospital in answer to the radio appeal for medical help. Within an hour or two after the first patient arrived, an estimated 60 doctors were working throughout the hospital.

Physicians were organized in plasma and operating teams of two, to start the flow of plasma into injured bodies in whatever way possible, to allay shock, the initial and perhaps most vital effect of severe burns. If injury was too severe to permit injection of plasma in the usual way, the patients were taken immediately to the operating rooms where a vein could be isolated by incision and the flow of life-giving plasma started. Then the more severe cases were put into oxygen tents. Doctors and nurses worked according to the pattern outlined by doctors in attendance following the Cocoanut Grove fire, morphine, plasma and oxygen were administered in the initial step; vaseline dressings were applied; stimulants were given by teams and tetanus anti-toxin administered to those who could take it.

While the medical staff gave immediate care to the casualties, members of the hospital's social service department were collecting and recording whatever identification data possible, with details of care already given, and tagging each patient. Within a few hours after the fire, a nurse's aide had been allocated to each patient and a graduate nurse to every one or two. Later in the evening family visitors were permitted, one to a patient.

After the patients had been transferred to the wards upstairs, medical teams circulated through the wards to evaluate the cases from

the medical point of view, considering heart, lung, and special conditions such as diabetes, and to prescribe further care.

At no time during the emergency did any needed drug run short. The hospital was well stocked with blood plasma and penicillin since the equipping of its bomb casualty rooms. Thirty-six units of plasma were on hand at the hospital, and more was obtained from the Red Cross, the government, Army and drug houses before the initial supply was exhausted. An estimated 150 units of plasma and of blood were used during the first four days, and it is still being administered in many cases.

Since penicillin was not used immediately in most cases, the amount used in the emergency cannot be predicted. Two orders for five million units have been received from drug laboratories, to supplement the hospital's 3,800,000 units on hand. All patients were placed routinely on sulfa drugs the first night, and this treatment was continued for 24 hours. Then all patients with fever were placed on penicillin.

Between 300 and 400 nurse's aides offered their services, and those who couldn't be immediately put to work were asked to stand on call. On Friday there were 332 on duty in the city.

While medical workers were absorbed in their grim task in the upper floors of the hospital, the regular service staff was busy trying to care for the hundreds of extra workers as well as the patients. The laundry staff voluntarily worked throughout their free week-end to keep the hospital supplied with clean sheets, doctors' and nurses' uniforms, and sterile equipment of all kinds. Volunteers from the Red Cross dietitian's aides and the Rolling Kitchen turned to with the hospital kitchen staff to feed the army of workers busy throughout the first night.

By 5 p.m. of the afternoon of the fire, seven extra telephones had been installed in the hospital, and extra switchboard operators placed on duty. Hugh electric fans have been installed in all corridors to ease the discomfort of the current heat wave, and hand fans were supplied so that each patient can be kept cool 24 hours a day by the attending nurse's aide. Oxygen tents were sent in by other hospitals, bringing the total in use at one time to about 40.

All patients admitted to the hospital, numbering 143, were treated even when they seemed beyond medical aid. As the strain lifted later in the evening, and it could be determined that certain patients could be moved without danger, a number were transferred to Hartford and St. Francis Hospitals to ensure the maximum of medical care for each.

A group of six fourth-year students from Yale Medical School, skilled in administering plasma and giving blood transfusions, came on Friday with a graduate interne and technician to assist in meeting the heavy demand for blood analyses. They will remain here for a week or more, working in shifts with the hospital staff. A committee of physicians who had charge of the Cocoanut Grove casualties came to Hartford when first word of the fire was received, to be on hand for consultation and assistance.

The hospital will depend for some time upon the volunteer efforts of many agencies, and the need for plasma and whole blood will be a continuing one, for many of the patients will be hospitalized for weeks or months.

Circus Fire Safety.

By Robert S. Moulton,

Secretary, N.F.P.A. Committee on Safety to Life.

Following the Hartford circus tragedy, fire protection authorities throughout the country have been concerned with the establishment of appropriate measures to prevent similar fires in other circuses. There are many inherent hazards in circus operation which cannot be completely overcome by any practicable measures, but various steps can be taken to reduce the hazard. The following suggestions indicate how existing N.F.P.A. standards may be applied to minimize the fire and life hazards. In most instances it should be possible to apply measures such as these without the necessity of enactment of any new legislation, for most cities have codes or ordinances applying to various aspects of life safety from fire in places of assembly, which broadly interpreted can be applied to tents and other temporary structures as well as to places of assembly housed in permanent buildings.

1. Exit arrangements should comply with the standard provisions of the N.F.P.A. Building Exits Code or with the local code which in many cases will be found to have provisions substantially equivalent to the Building Exits Code. This specifies for places of assembly on the ground level one 22-inch unit of exit width for each 100 persons, and includes provisions on all exit details.

2. Exits should be maintained free and unobstructed at all times when the tent is occupied. No temporary use of exit ways for performers, animals, ticket booths, or for any other purposes should be permitted to obstruct the minimum required exits. If operating requirements call for the temporary use during performances of exit spaces there should be provided sufficient additional exit facilities so that the minimum required exit width will be freely available at all times. Adequate aisle space must be maintained at all times to reach exits and, where necessary, fences or other suitable barriers should be erected to prevent encroachment upon the necessary aisles by parades of animals or other features in connection with the performance. If adequate exit facilities cannot be secured in the normal way through the center of the tent, stairs or runways may be erected at the rear of the stands, with adequate aisles leading thereto, so that it will be possible to escape directly outside of the tent at all points.

3. Circuses should not be permitted to operate except under effective supervision from the appropriate municipal or state authorities, with firemen or police or both on duty to make sure that exits are properly maintained, that no unusual features of fire hazard are introduced, etc.

4. All unnecessary combustible material should be eliminated from the tent and its immediate surroundings prior to every performance and where necessary collection of papers and rubbish should be continuous during performances. No papers or rubbish should be allowed at any time to accumulate under stands. All dry grass should be cut or burned before the tent is erected.

5. Tents, if possible, should be made of approved flameproofed canvas. Their flameproof qualities should be tested under fire department or other appropriate local supervision immediately prior to the opening of performances in any location. The method of testing given in the N.F.P.A. standards on Flameproofing of Textiles should be found suitable for such use. This will entail cutting out samples for tests, but the circus management should be prepared to patch areas of canvas cut out. Existing tents which have previously been waterproofed with paraffin and similar materials probably cannot be flameproofed effectively. In order to permit the use of such existing tents the hazard might be somewhat reduced by having all of the canvas, particularly the side walls near the ground, thoroughly wet down by the fire department prior to the start of each performance, with the wetting repeated at intervals. It should be noted in this connection that there is no assurance that there is any practicable method of eliminating completely the inherent hazard of the use of a canvas tent, but that flameproofing, wetting, or any other measures that may tend to reduce this hazard should be employed. Where weather conditions permit, the operation of a circus without any canvas over the center top portion should be a helpful factor in reducing the possibility of rapid spread of fire internally.

6. An adequate supply of first aid fire extinguishing equipment should be kept on hand ready for use at all times, and employees should be drilled in its effective use.

7. Electric wiring should be in accordance with the applicable provisions of the National Electrical Code.

8. No gasoline, gas, charcoal or other heating or cooking devices (e.g. peanut and popcorn machines) should be permitted in or near the main circus tent.

9. All other tents and enclosures on the grounds should be subject to the same requirements as specified for the main tent, if such other tents or enclosures are open to the public or are near any tents used by the public.

10. Advance arrangements should be made for prompt calling of the nearest fire department in case of fire or other emergency. A desirable plan used in some cases is to have the fire department on duty with charged hose lines.

Gardner Roberts.

Burning of the U. S. Government sponsored slum-like "trailer" camp after the plane crash.

Plane Crash Fire Kills Seventeen.

Seventeen persons, including five children, lost their lives and many others were injured when an army bomber crashed in the midst of the Westbrook Trailer Camp at South Portland, Maine, on July 11, 1944. The two men in the plane were among the victims. More than 300 persons, mostly women and children, who were in the camp at the time, were thrown into a panic by the crash, explosion and fierce fire that demolished the flimsy "trailers." The plane, a twin-engine job designated as an A-26b attack bomber, with a fuel capacity of approximately 400 gallons, was unable to land at the near-by airport because of fog. For reasons undisclosed, the plane struck the ground just outside the camp, bounced high into the air, exploded, and crashed again among the trailers, spreading death and destruction as flaming gasoline and oil showered the immediate neighborhood. The plane had refueled earlier in the day in Connecticut so it is probable that only a fraction of the total gasoline capacity remained in the tanks.

The "trailer" camp, owned and operated by the Federal Public Housing Au-

Gardner Roberts.

Ruins of the burned area. Note gasoline and oil drums.

Gardner Roberts.

One of the "trailers" on which parts of the plane fell.

thority, provided living quarters for shipyard workers and their families. It consisted of 100 plywood "trailer" units, each mounted on a foundation of posts or blocks and arranged in a staggered fashion, with an average interval of about 12 to 15 feet between trailers The camp was divided by three roadways, each forty feet in width and these were instrumental in confining the fire. Each trailer is heated by two kerosene burners located on either side of the entrance doorway, the fuel supply for which is contained in 50-gallon drums supported just outside on wooden "horses." Each trailer is equipped also with a gasoline stove for cooking. It is reported that the kerosene and gasoline supply for the trailers, ignited by the crashed plane, added to the intensity of the fire.

It is understood that the management of the camp considered itself exempt from all municipal regulations for the safety of trailer camps and was operated without benefit of permits for flammable liquids or other hazards.

There was no connection to the public fire alarm system in the camp area, but the alarm was sounded from the near-by Red Bank Village housing development. The South Portland Fire Department responded immediately and attacked the fire with hose lines supplied from public hydrants located outside the camp site. Simultaneously an engine company of the Portland Fire Department responded to the airport, believing the crash to have occurred there. They immediately proceeded to the trailer camp, where they laid hose lines from the one private hydrant installed in the camp. Unfortunately however, this hydrant operated in the opposite direction from the public hydrants in Portland and South Portland and in endeavoring to get water the stem of the hydrant was broken, whereupon the engine company was obliged to beat a hasty retreat. Eighteen trailer units, valued at $2500 each, were destroyed before the fire was finally extinguished. Several additional units were damaged. Many of the trailers were involved as a result of actual contact with the crashed plane, its parts, or showering fuel. Also destroyed was a general laundry house valued at $10,000. Preliminary estimates as reported in the newspapers place the damage at $100,000.

Fish Cannery Contest Awards.

The Fish Cannery Fire Protection Contest sponsored by Durham and Bates (members N.F.P.A.), of Portland, Oregon, has been brought to a highly successful conclusion. As announced in the January QUARTERLY, page 201, prizes totaling $750 were to be offered for the best solutions to the problem of providing adequate fire protection for canneries located at remote points along the northern Pacific Coast.

We are pleased to announce the following winners of the contest:

First Prize, $500—E. A. Taylor, Chief Deputy, State Fire Marshal Dept., Salem, Oregon.

Second Prize, $100—Charles N. Hagar, Great American Insurance Company, 1 Liberty Street, New York, N. Y.

Third Prize, $50—Lt. Orville Emory and Lt. Charles W. Bahme, U.S.N.R., 508 Van Nays Bldg., 210 West Seventh Street, Los Angeles, Cal.

Consolation Prizes, $25 each—

A. P. Chapman, 1815 West 62nd Avenue, Vancouver, B. C., Canada.

W. G. Shakespeare, Chief Inspector, Nova Scotia Board of Insurance Underwriters, 50 Sackville Street, Halifax, Nova Scotia, Canada.

E. B. Morrison, 6814 S. E. Reed College Place, Portland, Oregon.

Leslie I. Rowland, 168 Furby St., Winnipeg, Manitoba, Canada.

As a result of the contest Durham and Bates have received a great many valuable suggestions to help solve their fire protection problems. Certainly the time and effort expended on this contest by our many competing members will be put to good use.

Although we would like to publish the prize winning entries in full we can only give a summary of the highlights of one of these comprehensive and thoughtful papers, that of Mr. Taylor, who won first place. Many helpful ideas were also presented in the second-prize paper prepared by Mr. Hagar, and the third prize paper prepared by Lt. Emory and Lt. Bahme jointly. The publications furnished Mr. Taylor as an N.F.P.A. member played a prominent part in the preparation of this paper.

The prize-winning plan covers all conceivable hazards in the construction and layout of a typical cannery and recommends the most complete protection which could be provided within the limitations of location and weather conditions.

As to structural hazards, it is suggested that the severe exposure hazard of the wooden piling and platforms on which all the cannery buildings rest should be remedied by providing bulkhead cut-offs made by driving two rows of piling, lining with planks and filling the hollow space with dirt or sand. Although the nature of the occupancy calls for large-area buildings, they should have at least the protection of walkways around each building to permit taking hose lines around. It would also be very advantageous to install a walkway leading to the company store to discourage travel through the cannery and warehouse area. In planning future canneries, it would be desirable to isolate plant units on separate decks, the buildings to be connected by walkways covered with removable decking.

These recommendations stress the importance of a fire prevention program aimed at eliminating common hazards, as follows:

Replace defective heating and lighting appliances, replace sub-standard chimneys and stovepipes, install spark arresters on all chimneys and stovepipes, remove ashes and rubbish, store oil and gasoline in accordance with N.F.P.A. standards, store processed fish meal in small piles to prevent spontaneous heating, inspect steam pipes periodically to prevent contact with woodwork or combustible materials, whitewash liberally to encourage cleanliness and reduce susceptibility of wood to ignition, prohibit smoking when and where it is deemed hazardous, and during dry spells wet down docks frequently.

Of prime importance is the installation and maintenance of a dependable water

The hard-working judges in the contest are, from left to right, Mr. C. F. Wagner, Manager, Oregon Insurance Rating Bureau; Mr. A. L. Gile, President, Chinook Packing Co., Chinook, Washington; and Chief Edward Grenfell, Portland Fire Department, Portland, Oregon.

supply. A gravity system, to be augmented by a pumping system, is recommended with detailed suggestions as to location and types of installations which might be provided. A looped distribution system is suggested, to be provided with sectional valves to permit using part of the system when some other part may be out of service. There should be auxiliary 500 g.p.m. pumps, one at least to be mounted on a maneuverable float, barge, or boat and supplied with a deluge set or water gun. A pressure indicator should be conveniently located to warn of low pressure, in which event the auxiliary pumps could be used to maintain temporary water supply.

Hydrants are proposed where most desirable from a life safety standpoint when fighting fires, some to be frostproof where located on tne buried part of the system, others to be of ordinary type, as they will be on that part of the system which is drained during the cold season.

Adequate provision for hose houses is made, with fire fighters assigned to each. There must be a central fire alarm signal, and complete watchman service is considered essential. Automatic sprinklers are recommended if their installation is at all feasible, and first aid equipment is specified. Cellar pipes and augers for boring pipe openings should be required equipment for fighting under-pier fires.

In conclusion, the author of this prize-winning paper stresses the absolute necessity of a self-dependent fire department made up of plant personnel, with a fire chief who can make a success of the fire protection program, particularly the fire prevention phase of the program.

Methods of Employee Education.

By Charles W. Keating,
Republic Aviation Corp.

Ever since the discovery of fire, the world has been trying to discover a way to successfully put it out; and we are still trying. Within the last 100 years we have had fifty serious fires in the United States and we have had a hundred throughout the world that are classed as tops in disastrous results as far as life and property are concerned. Seventy-five per cent of the larger ones have occurred in North America.

In our enthusiasm we have all tried to "set the world on fire." Well, we have practically done so. Now it is up to us to try to put it out.

It is just a vicious circle. The new processes that are being developed today for anodizing and heat-treating, etc., present a problem to us, because as soon as someone invents a plastic or substitute material that will do a job more satisfactorily than before, then it is up to us to discover what it takes to extinguish it, if it will burn. Then something else is discovered and we have to go through the same steps again.

Industry has made great strides in the last ten years in fire protection. We have become fire-conscious because materials are not only hard to replace, they are almost irreplaceable. A great deal of money has been spent to develop fire protection for specific operations, but common everyday hazards still exist. In each plant there are all sort of hazards. It is up to you to do something about them.

At Republic Aviation Corporation, when a man is employed by the plant, we put him through an "induction program" of about two hours on the day he comes to work. He is given a very concise, yet complete, idea as to the hazards that exist in the plant. We also show him how to operate our different types of fire equipment; and impress upon him his responsibility in case of emergency. Also, he is given a complete outline of his duties. At the completion of this period he is taken on a tour of the plant and shown facilities, both emergency and ordinary, and we try to acquaint this individual with all the workings of the plant.

You wouldn't send a green army into war, so why send a green individual out into the war of hazards in the plant? One individual can completely destroy your plant in a few seconds, so don't let's take any chances.

We also ask the individuals in this induction class for suggestions to make this a better and a safer plant in which to work and live. We have even inaugurated a prize for the best suggestion each week, as an incentive for these men to put their ideas on paper.

New employees after attending an induction class prior to taking up duties of essential Thunderbolt fighter plane production, often do not wait long before using some of the instruction taught during the brief session.

The value of the introductory class was proven recently when a new member of the fire department, James Crecelius, prevented what would have been a serious fire, without yet having been given the special training all Indiana Division firemen receive.

The important demonstration on the use of fire extinguishers, given to all new employees at the induction class he had attended a few hours before, averted serious damage and injury.

Crecelius was in the factory when the whistle sounded for the 3 o'clock smoking period. In one of the main aisles he noticed a fire, and rushing to the scene saw another employee with clothing ablaze, standing in a mass of flame. Reaching for the nearest fire extinguisher, Crecelius extinguished the blaze on the man, and also the flames which were rapidly spreading beneath a Thunderbolt fuselage, covering an area of more than 15 feet.

Investigation disclosed that the careless employee had struck a match to light his cigarette in an area covered with naphtha. The man, working with the flammable

This article was presented as an address at the 48th Annual Meeting of the National Fire Protection Association, Philadelphia, May 9, 1944. The author is Fire Chief, Republic Aviation Corporation, Evansville, Indiana.

One of the induction classes looks on intently as the plant Fire Chief Charles Keating, aided by a class member, demonstrates the actual operation of a carbon dioxide fire extinguisher.

Fire Chief Charles Keating demonstrates the vaporizing liquid fire extinguisher to an induction class of employees at the Indiana Division of Republic Aviation Corporation at Evansville, Ind., where the famous P-47 fighter plane is manufactured.

A typical group of new employees, who will in a few hours be building Thunderbolt fighter planes at Republic Aviation Corporation at Evansville, Ind., attend induction class prior to beginning their work. Plant Protection Chief Charles Bridges is shown as he addresses the class on company rules, regulations and policies.

fluid, had spilled some on his shirt and over the floor. He was taken immediately to the plant hospital and treated for minor burns, and a short time later that day he was back on the job.

Crecelius had had no instruction on the operation of fire extinguishers previous to that given at the induction class. This was also his first experience with a fire of this type.

After a man leaves the induction program and goes to work we keep in contact with him through safety meetings, departmental meetings, parties, anything as long as we can get to talk to that individual.

It is essential that you have a mutual understanding with this man. Impress upon him first that you are trying to save his job; if you fail in your job, he hasn't got a job, so if he will help you he will be helping himself.

In foremen's meetings we try to impress upon the foremen their responsibility for the men under them. If these men do something wrong it is because the foreman has failed in the educational program.

In our induction program, we allow the men to handle equipment. They want to learn, and if they turn the extinguishers upside down and use them, it's all right. Just don't leave any doubt in the individual's mind as to the use of this fire equipment.

We have tried to hold fire brigade meetings not less than once every two weeks and in a very large plant that entails quite an amount of time and money. The men have to leave their work to receive instructions, to see the demonstrations or to participate in some type of training activity. The management of the plant, of course, has to coöperate in order to afford these individuals the company's time to put on this type of program. The management will be willing if you can show them tangible results.

The average plant is very fire-minded, but it is a salesmanship job on your part to get the complete coöperation of both management and men.

We consider it a very good idea to encourage participation in fire brigade work by some means of compensation. Of course, training and fire-fighting both are usually on company time, but a certificate of training is very well received by the men. We also provide badges in our plant. One plant that I know of gives war bonds for attendance at its fire training meetings. For a year's participation without missing a meeting, the reward is a $50 bond; for being present at all but two meetings a $25 bond is given. That plant also gives various cash awards and a dinner for the men.

Another thing we have done to further industrial fire protection in our part of the

country is to organize what we call the Ohio Valley Safety Council, a non-profit organization, through which we offer the services of experts free of charge to any plant within the area regardless of their problems, whether they are safety or fire. We make a survey of these plants and give them our recommendations as to how to better their fire protection methods or safety methods.

The response that we received was slow at first, but now we are receiving splendid coöperation from these plants. It is surprising to see the conditions that actually exist in some plants. At one particular magnesium plant, to which I was called, there was a machine which had been milling magnesium and which was subject to fires. They told me that apparently lightning had struck the machine. I found that throughout the plant large signs were posted, in the center of which was hung a carbon tetrachloride extinguisher, and the signs read, "For Use on Magnesium Only." The operator of the machine told me that when he applied the extinguisher to the burning magnesium he thought lightning had struck the place. Within a very short time I contacted the management of that plant and explained the danger of the situation. His only complaint was the fact that those signs cost him $25 each. I explained the situation to him and told him that if he didn't do something about the signs they would cost him his plant.

We have tried to help the individuals in our area who ask for help, and in the process we have benefited by acquiring the knowledge that comes from the inspection of numerous plants.

In our own plant we have tried to make it a practice to have a continuous inspection going on throughout the plant. We have men patrolling the plant twenty-four hours a day, giving it constant inspection.

We inspect our equipment once every eight hours, and that includes all fire extinguishers, and in a large plant there are quite a number of them, but we have found that through continuous inspection we eliminate numerous fire hazards. We do not have set routes for these inspectors. They come through each department once every hour, once every ten minutes, or once every five minutes, as they are detailed at the start of each shift.

If an inspector finds a hazard he calls the office and we go to work. It is not a matter of his writing it down and then at the end of the shift trying to get some action on it, because in the meantime the plant might burn down.

With the cooperation of one of the colleges in our region we have gone further in our fire protection education effort, and have started an industrial fire protection school consisting of a 74-hour course. The class is made up of plant safety directors, fire chiefs, and others from our area who want to know what happens when a sprinkler system goes off, how many different types of sprinkler systems there are, the chemical analysis of fire, etc. The last class was turned out about a month ago and we had twenty-six individuals who did not miss one hour. They wanted to learn. It is up to you whether or not they learn. Make your program inviting.

If you do a good fire protection job, don't feel too good about it. Try to make it a little bit better all the time.

Propane-Butane Truck Explosion.

Five people were killed and 21 injured in a liquefied petroleum gas transport truck explosion in Oklahoma City, March 31. This explosion apparently was due to failure to heed requirements of the N.F.P.A. Standards for the Storage and Handling of Liquefied Petroleum Gases. The resulting fire destroyed a lumber yard, one dwelling, a private garage, shed, a small storage building, and an automobile. In all, about 50 properties were involved to varying extents with damages totaling about $60,000.

Course of Events.

The transport truck, with 3,866 gallons of liquefied gases, consisting of two tanks of butane-propane mixture and two of propane, was following the route through Oklahoma City prescribed for flammable liquid transportation. Just after passing a small business section several people saw flames coming from the rear of the truck. The driver became aware of the commotion as people shouted at him, and stopped. While he telephoned the fire department, the truck rolled across the street until the opposite curb jarred it to a halt. It is thought that the fire burned the rubber air lines to the trailer brakes.

At 1:07 P.M. the fire alarm was turned in. Eight minutes later an explosion took place. Prior to this explosion, witnesses saw a pillar of flame shooting about 25 feet into the air every few minutes. It was noticed previously, also, that there was but one tank involved. The safety valve of the left butane tank had been functioning properly, and the gas was burning freely from this tank. It seems to indicate that the right butane tank's safety outlet was not operating.

First response by the fire department was with 2 pumpers, 2 foam companies, 1 squad, and 1 ladder company, the Fire Chief and an assistant chief. At 1:09 P.M. an additional pumper company was called. At 1:14 the property of the Long Bell Lumber Company had caught fire, and a second pumper was called.

The explosion of the right butane tank occurred at 1:15 as the first fire companies were going into action. The tank split along the right side, throwing flaming butane over a wide area. Two men trying to remove a small truck about 150 feet away from the fire in an alley were fatally burned. Four firemen 40 feet east of the burning truck were seriously burned. Some 15 other firemen were injured to a lesser degree.

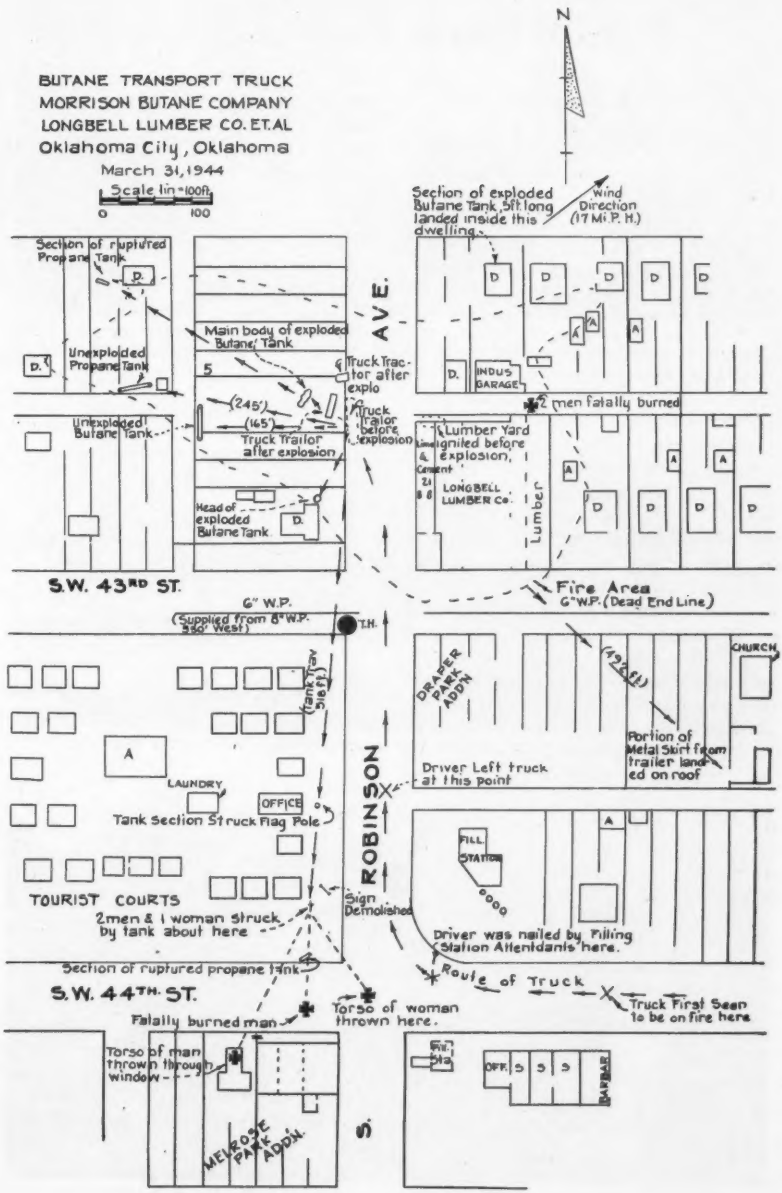
The front end of the exploded butane tank was thrown 183 feet northeast through the side of a brick veneered dwelling. The rear head was propelled 70 feet southwest, while the main body landed 50 feet west of the truck. The left butane and top propane tanks were hurled 165 feet and 245 feet to the west, but they did not explode, although gas discharging from the ruptured fittings continued to burn. The lower propane tank broke in two when hurled from the truck, and each section rocketed in opposite directions. The rear half, traveling 518 feet south, broke off a steel flagpole, demolished a signboard, and killed three people observing the fire from what appeared to be a safe distance. The front section smashed the rear part of a frame house 272 feet northwest of the truck.

Second and third alarms were turned in during the 3 minutes following the explosion. Additional equipment consisted of 6 pumper companies, 1 squad and 1 ladder company, and 5 chief officers. Six pumpers were connected to hydrants within 2 blocks of the fire area. Sixteen 2½-inch hose lines were laid, though the water supply available permitted the use of only 14 of these.

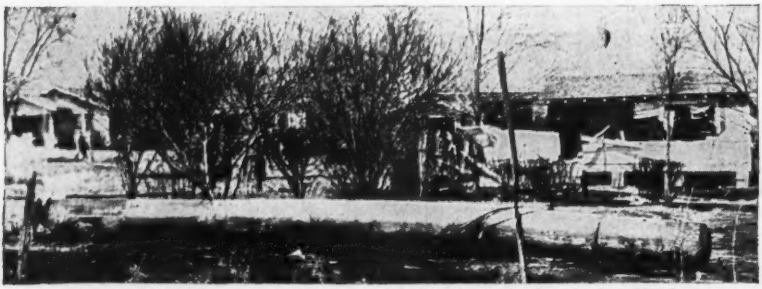
The lumber yard was involved almost immediately and the fire spread from it to the frame dwelling and ironclad storage building 25 feet north across the alley, then to a private garage 15 feet east. These were all total losses. By 2 P.M. the fire was well under control.

Truck Construction and Equipment.

The butane-propane transport truck was of semi-trailer type, dual wheels, air brakes, and butane engine fuel tank. (This tank was only slightly damaged during the


BUTANE TRANSPORT TRUCK
MORRISON BUTANE COMPANY
LONGBELL LUMBER CO. ET. AL
Oklahoma City, Oklahoma
March 31, 1944
Scale 1in = 100ft.
0
100
N
Section of exploded Butane Tank 5ft. long landed inside this dwelling.
Wind Direction (17 Mi. P. H.)
Section of ruptured Propane Tank
Unexploded Propane Tank
Unexploded Butane Tank
Main body of exploded Butane Tank
Truck Tractor after explo
Truck Trailor before explosion
Truck Trailor after explosion
Head of exploded Butane Tank
AVE.
INDUS GARAGE
2 men fatally burned
Lumber Yard ignited before explosion.
LONGBELL LUMBER Co.
Lumber
S.W. 43RD ST.
Fire Area
6" W.P. (Dead End Line)
6" W.P. (Supplied from 8" W.P. 350' West)
T.H.
DRAPER PARK ADDN
CHURCH
Portion of Metal Skirt from trailer landed on roof
Driver Left truck at this point
ROBINSON
LAUNDRY
OFFICE
Tank Section Struck Flag Pole
TOURIST COURTS
2 men & 1 woman struck by tank about here
Sign Demolished
FILL. STATION
Driver was nailed by Filling Station Attendants here.
Section of ruptured propane tank
Route of Truck
Truck First Seen to be on fire here
S.W. 44TH. ST.
Fatally burned man
Torso of woman thrown here.
Torso of man thrown through window
MELROSE PARK ADDN.
OFF.
GARAGE

View of the burning tractor of a semi-trailer type transport truck carrying 3,866 gallons of propane and butane which caught fire and exploded in Oklahoma City on March 31. Five persons were killed and 21 injured.



This unexploded propane tank was hurled through the air for 245 feet.

Unexploded propane and butane tanks are seen in the foreground, lumber yard destroyed by fire in the background.

A section of ruptured propane tank caused this damage, typical of damage done to numerous dwellings in a 500-foot radius.

whole explosion and fire.) The over-all length was 43 feet 4 inches.

The truck had been placed in service in 1940 as a liquefied petroleum gas distribution unit and was converted to the semi-trailer type in September 1943. The original tank construction and converted tanks were said to have been inspected and approved by authorized persons and had conformed to the ASME Code for Unified Pressure Vessels.

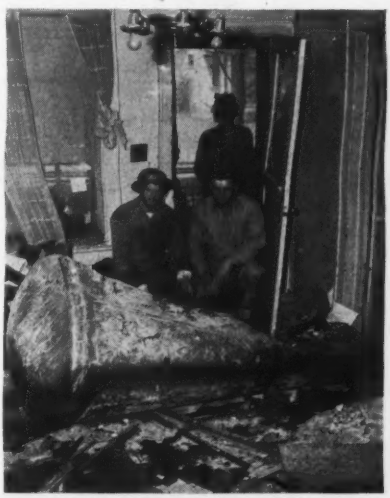
Four tanks were mounted on the trailer; 2 of these, 36 in. in diameter, 30 ft. 8 in. long, with capacities of 1,526 water gallons each, were butane tanks. The propane tanks were 20 in. and 24 in. in diameter, 25 ft. 10 in. and 30 ft. 8 in. long, with capacities of 416 and 668 water gallons respectively.

Each tank was equipped with a rotary tube liquid level gauge, a 90 per cent capacity bleed valve gauge, pressure gauge, temperature well, filling and vapor return connections with check valves. These were all located on the rear heads of the tanks.

The butane tanks were mounted on each side of the trailer with propane tanks between, the shorter on the bottom. The rear end of tanks and all devices connected thereto were enclosed with sheet metal housing having double access doors. A positive displacement pump for liquid transfer was mounted on the right frame of the tractor near the cab. Connections from each tank to pump intake header were equipped with excess flow check valves. Flexible rubber hose connections were used for the pump and were disconnected when not used. A static drag chain was said to have been provided.

Safety relief valves of the spring-loaded type for the butane tanks were mounted on the top axis at the center of each tank. These valves were set to operate at 125 lbs. pressure and discharged to the outer air; their relief areas were 2.2 sq. in. each.

For the propane tanks there were spring-loaded type valves, three for each tank. Each had .3 sq. in. relief area, set to operate at 240 lbs. pressure. Investigations showed that these six relief valves apparently did not discharge into the outer air, as they were mounted on the rear heads of tanks and enclosed in the metal compartment at the rear of the truck. The safety valves for one propane tank were on a 1-in. connection common to the three valves; others had individual connections. All valves were stated to be above liquid level in any circumstances.



The end section of exploded butane tank which hurtled 183 feet and crashed through the side of this dwelling.

Behavior of Safety Valves.

The safety valve on one tank of butane and on both tanks of propane apparently functioned and prevented their exploding. After the fire was out, one of the butane tanks and the 24-in. diameter propane tank still contained some liquid. The tanks did not rupture completely during the ac-

cident. The 20-in. propane tank was unquestionably broken in two by the bursting butane tank. There was no evidence of heat or pressure distortion on the two halves of that tank, indicating that the liquid remained in that tank up to the moment of its breaking in two from outside forces.

The remains of the exploded butane tank definitely indicated to investigators that the vapor in a certain area of the exploded tank had been confined under pressure, prior to the explosion, not able to escape through an inoperative safety valve. When the heated tank shell, principally near the top rear surface, got red hot, it bulged, blistered, and the expanding gas finally reached the bursting point. However, with the intense flame impinging on the tank there is some doubt as to whether the safety valve would in any case have been adequate to relieve the excessive pressure created by conditions far more severe than contemplated in the design of such safety relief facilities.

Inspection of the lower part of the 2-in. safety valve from the 36-in. exploded butane tank showed that it had been screwed into a heavy duty coupler. This had been welded with about one-half its length inside the tank. The arrangement was such that the coupler had partially constricted the 1-in. holes serving as entry ports into the valve proper. However, this partial covering of the openings in the valve was not believed to have been a factor in the explosion.

Conclusions.

The cause of the fire and why the flames were of such extent at incipiency have not been definitely determined. It appears that the flames at the rear of the truck may have been fed from gases discharged from a leak in the tank or fittings. The vapors could have caught fire from any number of causes: sparks from the static drag chain, a spark from the engine exhaust, or a discarded cigarette.

The burning gases in the enclosed rear compartment would tend to heat tanks, causing discharge of additional fuel from the propane tank relief valves. A sort of propane fuel fed furnace was the result.

Had the propane tank relief valves been properly arranged to discharge into the open air in accordance with recognized N.F.P.A. standards, it is doubtful that an explosion would have occurred, irrespective of the truck fire.

An accident and explosion such as this demonstrates forcibly the need for adequate safety measures pertaining to the transportation, storage, and handling of liquefied petroleum gases. Oklahoma state requirements regarding liquefied petroleum gases are said to conform substantially with standards of the National Fire Protection Association. These should have been supplemented by suitable local regulations. Oklahoma City officials are now preparing an ordinance governing this hazard.

Steel Piping for War-Time Fire Fighting.

Abundance of water is the primary requirement when fighting fires, particularly under air raid conditions. In most areas peace-time standards of water supply are inadequate for war-time necessity, and fractures in mains caused by bombing can lead to the cutting off of large areas from all sources of mains supply. To overcome these problems under actual fire fighting conditions water relaying, with hose laying lorries using 2½-in., or preferably 3½-in. diameter hose, has been widely adopted. Whilst this method will make water available after its provision has been rendered necessary by fire, it is impracticable as a method of guarding, in advance, against shortage in any area, and, further, has the disadvantage that the quantity of water provided by a relay, even when using 3½-in. diameter hose, is relatively small. As a result of these requirements a system of steel pipelines, which can be easily and quickly laid above ground by unskilled labour, has been evolved.

Use of Pipelines.

The use of such pipelines can be classified under two main heads.

(a) When laid in advance of anticipated air attack, in order to ensure that water in sufficient quantity shall be immediately available for firefighting.

(b) When laid during or immediately after an attack, in order to provide water to the area, or to supplement existing, but inadequate, supplies for firefighting.

The main functions under (a) above may be listed as:

(i) To anticipate water mains failure by providing a secondary supply from open or static water. This secondary water mains system, although apparently open to the same objections as the existing mains, is very much less vulnerable and has the advantage of being accessible. In consequence it is easy to repair and replace damaged lengths of piping.

(ii) To provide a semi-permanent supply to areas without an adequate water mains supply, or where the existing supplies would be inadequate to deal with the fire risk. The advantage here is the protection of a factory or high fire risk in country or isolated areas, where possibly only a small domestic water supply is available.

(iii) To link up emergency water supplies.

The main functions under (b) may be listed as:

(i) To provide, during the attack, water in greater quantities than is possible with a hose relay.

(ii) To provide protection, after the attack, until the mains system is restored; and also to give a supply for cooling down, refilling dams and basins, etc., in anticipation of further attacks.

The advantages of steel pipelines as against water relaying using hose may be summed up as:

(i) A very much greater capacity is obtainable. A single line of 6-in. steel piping, for example, if laid with a minimum of tee pieces and other fittings, so as to avoid undue friction loss, will deliver at least 1,000 g.p.m. [1,200 U. S. g.p.m.]; whereas a relay using twin lines of hose at a comparable pressure will only deliver 350-400 g.p.m. [400-500 U. S. g.p.m.].

(ii) Steel pipelines are very much less vulnerable than hose lines, can operate at higher pressures; are not subject to bursts and are resistant to damage due to falling objects such as débris from buildings.

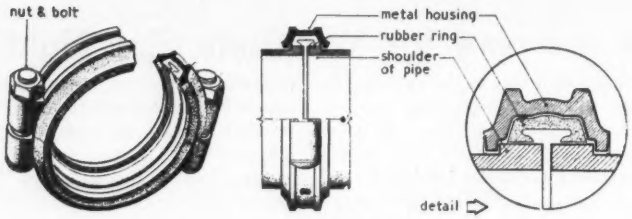
(iii) Considerably fewer pumps are required to give the same output, with consequent saving in manpower once the pipeline has been got to work.

The disadvantages are:

(i) Piping takes longer to lay.

British experience in the development of emergency water supplies for fighting air raid fires should be of interest to all N.F.P.A. members, as a basis for planning not only for possible future air raids, but to meet various other emergencies when normal water supply facilities may be disrupted. We are accordingly printing the official British account based upon the experience of two years of war. See also April, 1944, Quarterly, p. 268. It is published by permission of His British Majesty's Stationery Office through the courtesy of the British Information Services (Crown copyright reserved). The diagrams and the text are from the Manual of Firemanship (Part 3) by and for Britain's National Fire Service. The text is reproduced without change, with editorial notes in parentheses where terms different from those ordinarily used in U. S. and Canadian practice are employed.

Parts 1, 2 and 3 of the Manual of Firemanship of the British National Fire Service are now available. They may be obtained for 75 cents, for each part, from British Information Services, 30 Rockefeller Plaza, New York, N. Y.



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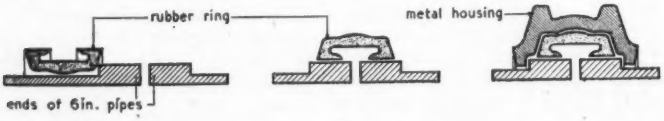
Victaulic joint. Left: cut-away view, showing rubber ring. Centre and right: sections showing ring in position.



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Sketch showing correct method of fitting the rubber ring when making a victaulic joint.

(ii) The weight of the equipment and materials is greater and the length of the pipes normally requires special vehicles for transport.

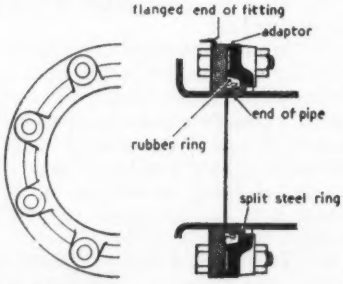
(iii) It is very much less flexible than hose, the victaulic couplings permitting adjustments of 1 deg. only, and if awkward bends must be negotiated, special fittings must be used, thus slowing up the rate of laying.

(iv) Owing to the greater diameter, ramping, where traffic must cross the pipeline, is more difficult.

The method of laying and the choice of fittings will depend to some extent on whether pipelines are to be prelaid or laid during firefighting operations. In the former case, the route will be dictated by probable requirements in the area to be served, and, in the latter case, solely by the shortest practicable distance between a suitable source of water and the locality where it is required. Whichever method of laying is adopted there is no difference in the design of the pipe or its fittings.

Six-inch Steel Piping and Its Fittings.

(a) Piping and Joints. The pipes used in this system are of steel, and are issued in what are known as "random lengths," normally ranging in length from 16 ft. to 23 ft., but shorter lengths (half- or quarter-random lengths, i.e., lengths between approximately 8 and 12 or 4 and 6 ft. respectively) may be used for special purposes. They are connected by means of a special type of rapidly completed joint known as a victaulic joint. In this system the ends of the pipe, each of which has a small shoulder, are laid close to one another, and a special composition rubber ring and a metal housing constructed in two halves, is placed over the ends and kept in position by two bolts. The construction of the rubber ring is such that it is forced by the pressure in the pipe against the shoulders on the pipes, thus making a leakproof joint. The rings are so designed that they are also self-sealing when the pipeline is operating at pressures below atmospheric.



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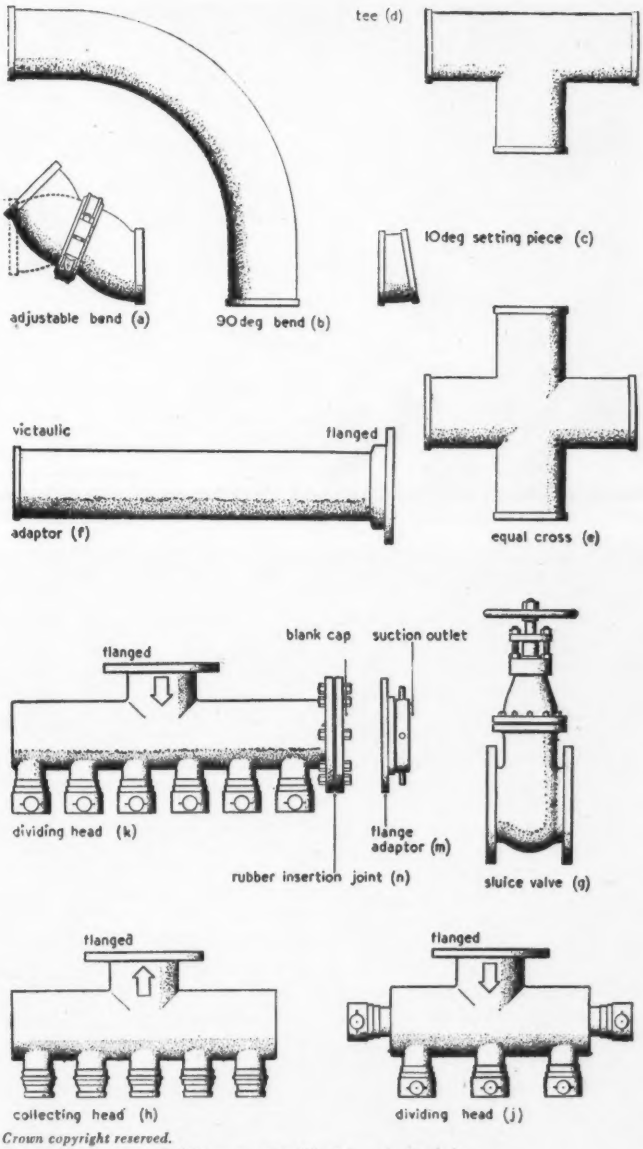
Adaptor, flanged to victaulic (later type). Left: half end view of adaptor in use to join a flanged fitting to steel piping.



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Fittings used with 6-in. steel piping.

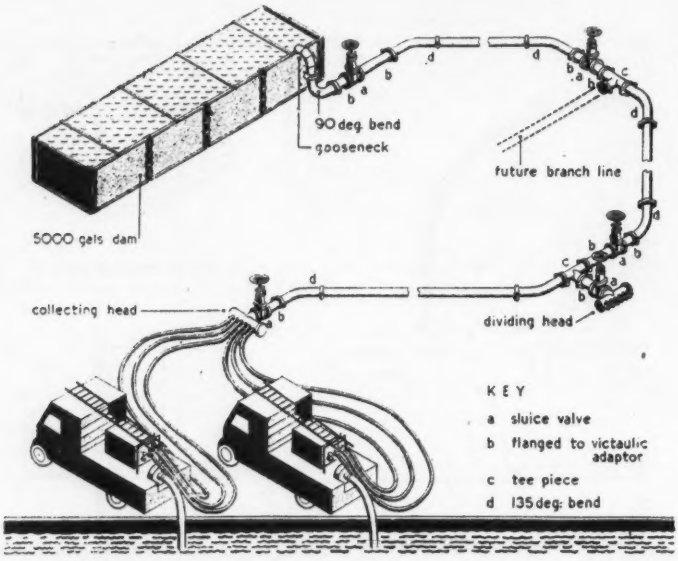

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Diagram showing method of connecting up pumps to steel piping and use of the principal fittings.

(b) Spanners. No special spanners are issued for tightening up the nuts and bolts on the couplings, but some Fire Forces have fabricated wheel-brace type box spanners which are very effective where the joint is not in a confined position. Tee spanners and ratchet box spanners also have the virtue of speeding up the work considerably.

(c) Fittings. A number of different fittings are used with this system [Illustrated].

In the case of prelaid pipelines which it is intended shall remain in position for a considerable time, it will usually be found more economical in fittings, and hydraulically more efficient, to construct special bends, etc., to suit the run of the pipeline. This may be done either by cutting lengths of pipe with an oxy-acetylene outfit and welding them to the desired contours, or, where fairly large radius bends only are in question, by heating the pipe in a forge and bending it to the required curve. Plates 1 and 2 show this work being carried out, and in Plate 3 is illustrated a typical example of piping bent to follow the contour of the kerb (curb).

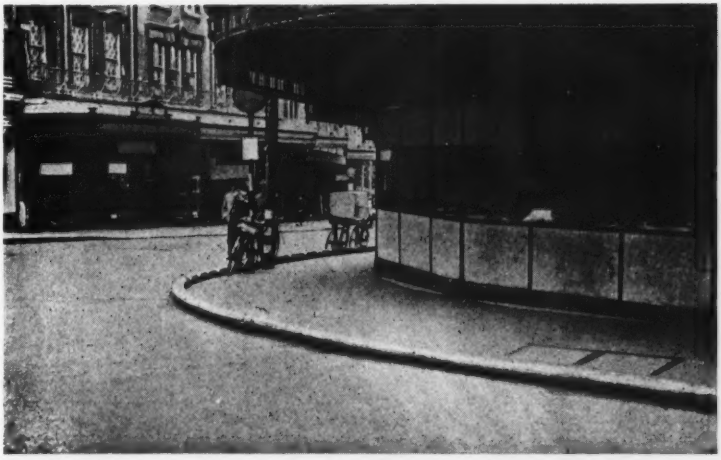
Planning Pipeline Routes.

The layout of a typical pipeline, showing the use of the various fittings is given [Illustrated]. When pipelines are to be prelaid, the route will be governed entirely by local considerations, and it is, in consequence, impossible to do other than outline certain general requirements. These are:

(a) It is always undesirable for pipelines to follow exactly the course of the street water main system below ground, since bomb damage which affects one will then in all probability affect the other.

(b) The lines should be planned, and the pump spacing arranged, so as to ensure the delivery of not less than 1,000 g.p.m. [1,200 U. S. g.p.m.] at 100 lbs. per sq. in. pump pressure.

(c) Every opportunity should be taken to link up static supplies such as dams [tanks], flooded basements, etc. When planning the layout, it may sometimes be found desirable to arrange the fittings so that water may, if necessary, be pumped in the reverse direction.



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An excellent example of 6-in. steel piping bent to follow a curve.

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Six-inch steel piping laid in chase. Note the deviation to miss the street gulley and blanked off tee to which an outlet can rapidly be fixed if required.

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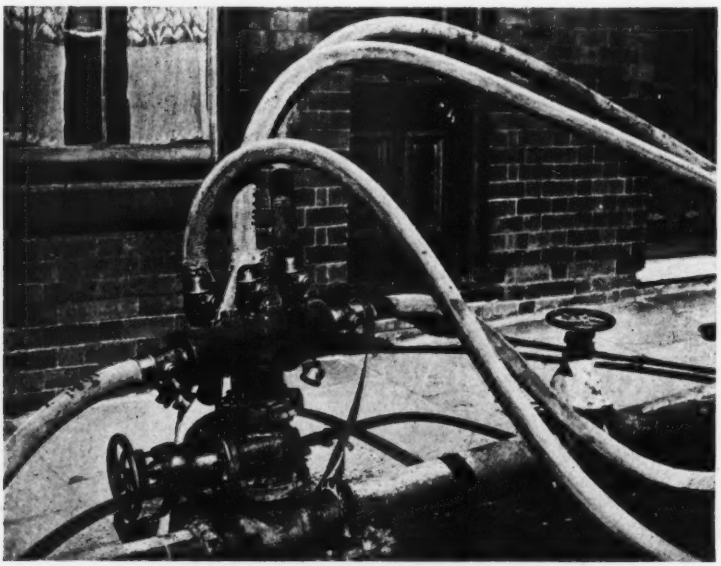
Pipeline collecting head, showing hose coupled up with valve connected to adaptor piece.



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Pipeline dividing head, showing sluice valve bolted to tee-piece.

(d) The maximum use should be made of bends, etc., fabricated from pipe by welding; these will reduce the number of special fittings required. A certain number of oxy-acetylene welding sets have been provided [to the National Fire Service] for this purpose.

(e) Provision should be made for suitable booster points, and careful consideration should be given to the location of outlets at suitable points on the pipeline. It should be appreciated that such outlets are alternative to one another and should not be used simultaneously, since the capacity of the normal pipeline is insufficient to supply several outlets at full flow. A booster point consists of an arrangement of valves and fittings, whereby a pump or pumps can be set into a line at work and used to raise the pressure in the line and so increase its capacity. The arrangement of the fittings at a booster point is shown [Illustrated].

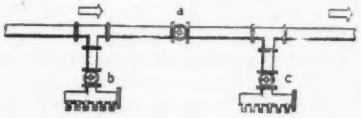

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Diagram showing the arrangement of a booster point. The valve (a) is normally left open so that water can be pumped along the line as shown by the arrows. When, however, it is desired to boost up the pressure and so increase the capacity of the line, two or more pumps (according to the pumping capacity necessary) are set in and connected, the suction to the delivery head (b) and the delivery hose to the collecting head (c). The pumps are then started, the valves (b) and (c) opened and the valve (a) closed.

(f) The pipe should normally be buried below the road surface at road intersections or where it would prove a serious obstruction and require ramping.

(g) When the pipe is being laid in the gutter and is likely to be down for a long period, the pipe should be whitened, preferably with paint, in order to warn pedestrians and traffic of its presence during blackout. Some local authorities require that it should not be laid in the gutter, owing to the obstruction of the drainage and of gullies which require cleaning.

(h) Adequate provision should be made for possible extensions, and at points where it is or may in the future become necessary to take a branch line off the main pipeline a teepiece should be inserted, or where a line on either side of the main pipe is required, a cross should be employed. Such tees may be blanked off if not required immediately to complete the projected extension.

(i) The discharge end of the pipeline should be fitted with a valve so that the flow can be cut off to feed any intermediate outlets if these are to be used.

(j) Adequate arrangements must be made to drain the pipeline in cold weather and suitable drainage points should be arranged.

The Transport of Piping.

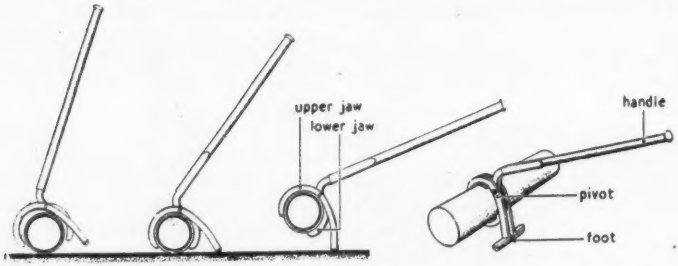
Transport presents somewhat of a problem owing to the weight of the fittings and to the length of the pipes. Special six-wheel articulated vehicles form the ideal medium of transport where available. Their loading will, of course, vary with the make of vehicle. Where such vehicles are not available, transport must be provided which is capable of accommodating pipes of the maximum length of 23 ft. and will yet permit of the easy removal of the load pipe by pipe, as the route is traversed.

Pipe Laying.

Laying prelaid pipelines will, of course, be carried out with the labour available, and since the same degree of urgency as when laying during a raid will not obtain, the pipes will be sited more carefully and the whole work carried out more in the manner of an engineering undertaking.

When laying during a raid, however, the utmost possible speed is necessary. The route will be dictated by the shortest practicable distance between supply and fireground, and the same regard will be had to possible obstruction, etc., as would apply in the case of a relay.

To achieve rapid laying under raid conditions crews must be carefully organized, and made familiar with their duties by regular drills. Correct stowage of the piping and fittings on the pipe carrying lorries is also an important factor, accessibility and ease of removal being the prime considerations. Pipelines laid under raid



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Sketch of pipe tongs used for laying 6-in. steel piping.

conditions should be simplified as much as possible by the elimination of all but essential fittings, so that the lines can be laid directly from supply point to delivery point without interruption.

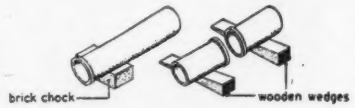
When separate lorries are used for piping and fittings, a crew of twelve men (including the two drivers) is normally sufficient. The men are disposed as follows:

2 drivers.
1 man on the pipe lorry rolling the pipes into position for unloading.
1 man on the pipe lorry tender handing off fittings.
2 men unloading pipes from the pipe lorry and laying them in their approximate positions.
1 man unloading fittings and placing them in their approximate positions.
2 men with pipe tongs each lining up the pipes for jointing.
2 men making the joints.
1 man following up tightening nuts and bolts.

Any additional pipe or fittings lorries will require drivers only, since the crew from the first lorries will take over the unloading and laying. The jointers and the tong men work in pairs making up alternate joints.

In laying out the piping, the pipe carrying lorries should, where conditions permit, traverse the route, followed by the lorry carrying fittings and joints, which will be deposited as previously determined by the officer who has surveyed the route. The pipeline should be started with a pipeline collecting head [Illustrated], leaving sufficient room between the collecting head and the open water for the pumping units to be placed in position and for connecting the pumps to the collecting head by the necessary number of hose lines, which should in all cases be as short as possible. In general it is better for joints to be made length by length, working from one end of the pipeline to the other. Should the line, however, be laid to include one or more intersections, the operation can be speeded up by the provision of further parties who would commence on each of the sections simultaneously. Advantage should also be taken of working from each side of hose crossings, etc.

Where the tongs described below are not available, bricks can be obtained from dumps or débris near by for use as chocks, and thin wood wedges not less than 12 in. long and cut to rather a fine taper, say between 10 deg. and 15 deg., will be found very useful in trueing up pipes preparatory to the making of joints [Illustrated].



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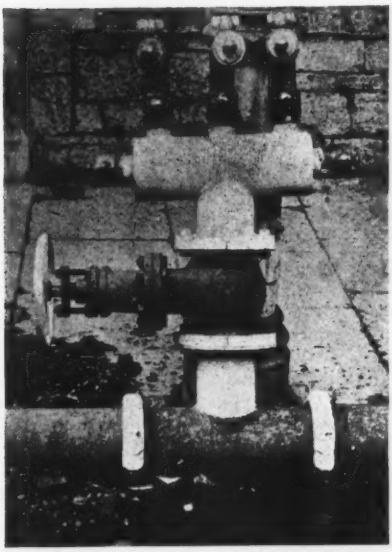
Sketch showing method of using chock (left) and wedges (right) to align pipes for jointing.

A form of tongs [Illustrated] has recently been evolved to facilitate lifting and jointing. The tongs consist of two semicircular steel jaws of 6 in. internal diameter, pivoted about an axis pin. The lower jaw is continued upwards to form a lever or handle about 3 ft. 6 in. long, and the upper jaw is continued downwards to terminate in a foot. The pipe is seized between the jaws, and downward pressure on the handle brings the foot into contact



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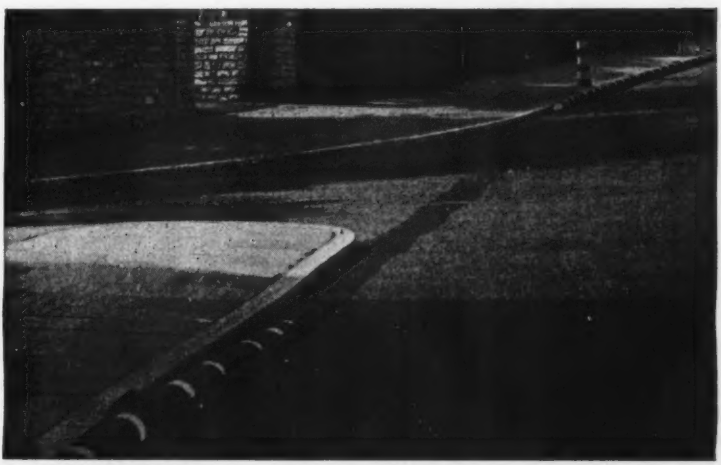
Pipeline dividing head erected against a lamp-post, which reduces obstruction and probability of damage.



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Pipeline in chase, showing gentle inclination in foreground and specially bent pipe in distance.

with the ground, allowing the axis pin to act as a fulcrum.

Either one or two pairs of tongs may be used in the making of a joint. In the former case each length of pipe is lifted in turn and chocked with a wedge until approximate alignment is achieved. The tongs are then used astride the adjacent shoulders to produce complete alignment, the wedges re-adjusted and the tongs removed, leaving the pipe ends ready for application of the rubber ring and metal housing.

In the alternative method, using two pairs of tongs, a man with a pair of tongs in each hand grips the two pipe ends and manipulates them into juxtaposition. While they are so held the joint is made between the two pairs of tongs. No wedges are needed in this method.

Another tool which has been developed to assist in speeding up laying operations is shown [Illustrated].

Starting at the supply end of the pipeline the fittings and piping should therefore be connected up as follows:

Collecting head.
One 6-in. sluice valve.
Adaptor from flanged joint to victaulic joint.
The first length of piping.

Where practicable, crossing major roads and interference with traffic should be avoided. If such crossings are unavoidable one or other of the following methods may be adopted:

(a) Bridging the pipeline over the intersecting road.

(b) Cutting a chase in the road and sinking the pipe.

(c) Crossing the road by means of ramped hose lines.

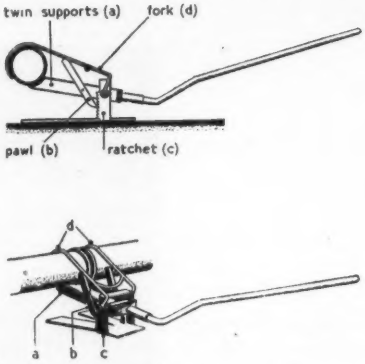
(d) Ramping the piping.

Of these methods, (a) and (b) are normally applicable only to prelaid pipelines, and method (b) is to be preferred owing to its greater simplicity, lack of obstruction and economy in the use of fittings.

Methods (c) and (d) will normally be employed for piping laid during or immediately after raids.

Protection Against Damage.

Where pipeline collecting heads and dividing heads are located in thoroughfares, they should be protected against damage by vehicles, etc., and should also be rendered conspicuous [Illustrated] in order not to prove dangerous to pedestrians. Many methods of carrying this out have been used, including the construction of wooden boxes, precast concrete slabs, etc., the primary consideration being ease of access when the pipeline is required. Such protection is normally painted white in order to render it more easily visible at night.



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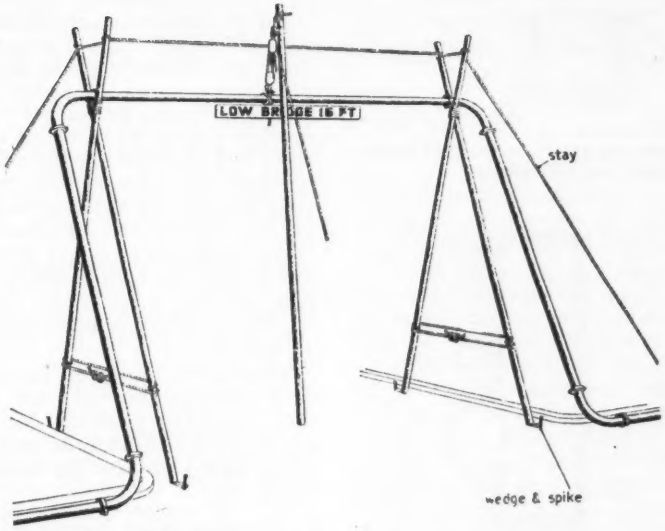
Sketch showing another type of pipe tongs used for laying 6-inch steel piping. This consists of a manually operated lever jack which has twin supports (a) to enable the ends of two adjacent pipes to be lifted simultaneously to the same height. A counterbalanced pawl (b), by engaging a ratchet (c), allows the jack to be left unattended, holding the pipes at the required height. Attached to the upper side of the jack is a double pronged fork (d) terminating in a semi-circular claw of 6 in. diameter which falls into position over the top and far side of the pipes. When the handle is depressed the pipes are raised on the twin supports, being held in position by the claws, which also give lateral alignment. The space between the claws and the twin supports allows the coupling to be placed in position on the pipes before the jack is removed. The rubber ring should, of course, be placed over one pipe near the shoulder before starting the operation.

Frost Dangers.

The most usual places for the formation of pockets of water are where, owing to the contour of the ground, or the chasing of the pipe under roads, water cannot be eliminated by drainage through collecting



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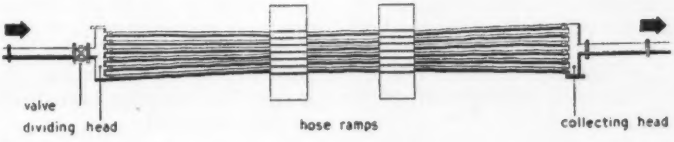
Method of bridging 6-in. steel piping.



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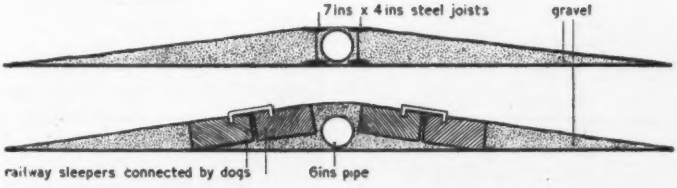
Arrangement of a hose crossing.



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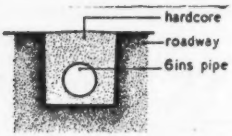
Methods of ramping steel piping. Above: arrangement using two 7-in. by 4-in. rolled steel joists and well-rammed hardcore. Below: old wooden railway sleepers connected by dogs.



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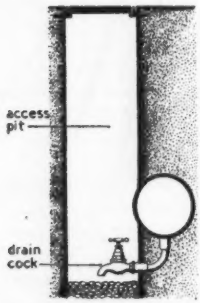
Steel piping laid in a chase filled with well-rammed hardcore.



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Sketch showing possible method of constructing a drain for piping laid below ground level.

or dividing heads. Freezing at such points may take place very rapidly, and pipelines should always be carefully drained when there is any likelihood of severe weather. [Freezing weather is relatively infrequent in England.]

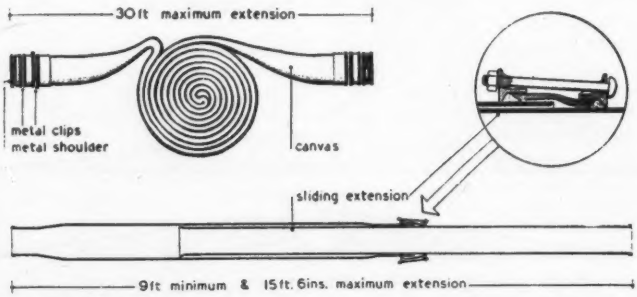
Repairs.

For the purpose of expediting repairs, random length of from 4 to 6 and 8 to 10 ft., and lengths of piping in the form of adjustable sleeves [Illustrated] are now available. To date, two sizes of sleeves are in production (9 ft., extending to 15 ft., and 4 ft. 6 in., extending to 7 ft.). Difficult gaps may, if necessary, be crossed by using dividing and collecting heads in the same manner as for a road intersection. A certain number of lengths of flexible 7-in. piping have also been provided, fitted at each end with shoulders for connecting into the pipeline by means of the standard victaulic joint.

These can be dispatched, together with other miscellaneous equipment, to incidents involving pipelines damaged by enemy action, in order to re-establish continuity of supply with the minimum of delay.

Communications Along Pipelines.

Adequately to control the pumping arrangements along pipelines, efficient means of communication are essential. Any of the recognised methods, such as hand signals, or semaphore, may be employed, in addition to, or in substitution for, a system of messengers on foot, cycle or motor cycle. Field telephone lines, either prelaid or run out when the pipeline is brought into operation, have also been successfully employed.



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Methods of repairing 6-in. steel piping. Above: flexible 7-in. piping. Below: adjustable sleeve length.

Large Spherical Compressed Gas Containers.

By J. B. Smith,
Associated Factory Mutual Fire Insurance Companies.

On February 16, 1943, at the General Electric Company, Schenectady, New York, a 38-ft. diameter sphere containing hydrogen gas compressed to 50 lb., suddenly burst.

The purpose of this paper is to describe the events attending the accident, the method of investigation which finally discovered the probable factors involved in the cause, and to call attention to the lessons. The accident is of unusual interest in that it is the largest high pressure gas container which we have known to have suddenly ruptured. In addition it is the only one of about 500 spheres erected which has failed in service. It is hoped that the technique used in the investigation will be useful in the future.

Story of the Accident.

The accident occurred on a clear cold sunny day at 2:47 P.M. E.W.T., at a temperature of 10° F., following an unusually rapid rise of 27° during the seven-hour period prior to the failure. The sphere had been isolated from all piping since a small amount of hydrogen was added by pumping at about 7 A.M.

Accompanied by a deep heavy sound, which was felt rather than heard, the 65-ton, 5/8-in. thick sphere burst into about 20 fragments which were thrown in all directions. The piece thrown farthest weighed 7½ tons, traveled 575 ft., over an 80 ft. high building and came to rest in a creek. Of the 650 ft. of fracture only a few feet followed in the total of about 2000 ft. of welded seam, proving the good strength of the joints themselves. The fractures did not involve, except in a minor way, the support leg attachments where there are extra stresses due to the loads from the dead weight of the sphere.

Owing to the suddenness of the accident, there was very little reliable testimony as to whether or not the hydrogen burned after its release. One witness who happened to be overlooking the scene from a high office building about a mile and a half distant, stated that he saw a red flame rise above the sphere site, mushroom out, then disappear, all in the space of several seconds. Fragments of the sphere struck the nearest building about 12 ft. distant, demolishing a large section of poured gypsum roof and brick wall, also distorting the steel framework. Interior tile partitions were blown over and the spiking of roof planks was withdrawn about ½ in., on buildings up to 300 ft. distant. Most of the 14 in. by 20 in. double strength window glass in steel sash in walls facing the sphere was broken as far as 1000 ft. away. Scattered windows, particularly large plate glass panes, were broken at distances up to two miles. The shock was felt in buildings in Albany and Watervliet, about 14 miles away.

Description of Sphere.

The sphere plates were arranged in five zones; the top and bottom zones or saucers contained two plates each and the three intermediate zones sixteen plates each. The vessel was designed substantially in accordance with Paragraph U.69 of the ASME Code for Unfired Pressure Vessels. The plates were of a commonly used A.S.T.M. A70 Firebox grade of steel, shop formed cold and erected in the field in October of 1942. The joints were welded, using covered electrodes, and, in accordance with the Code, were not stress-relieved afterwards. The sphere stood on four concrete footings carried 5.5 ft. below grade. Backfilling for buried piping was only partly completed and loosely packed. From each footing two steel angle support legs diverged and were welded to support pads symmetrically spaced around the horizontal seam just below the center zone. At the point of attachment, the sup-

This article was presented as an address at the 48th Annual Meeting of the National Fire Protection Association, Philadelphia, May 11, 1944. The author is an Engineer, Inspection Department, Associated Factory Mutual Fire Insurance Cos. For discussion of this address see Proceedings, printed as Part II of this Quarterly.

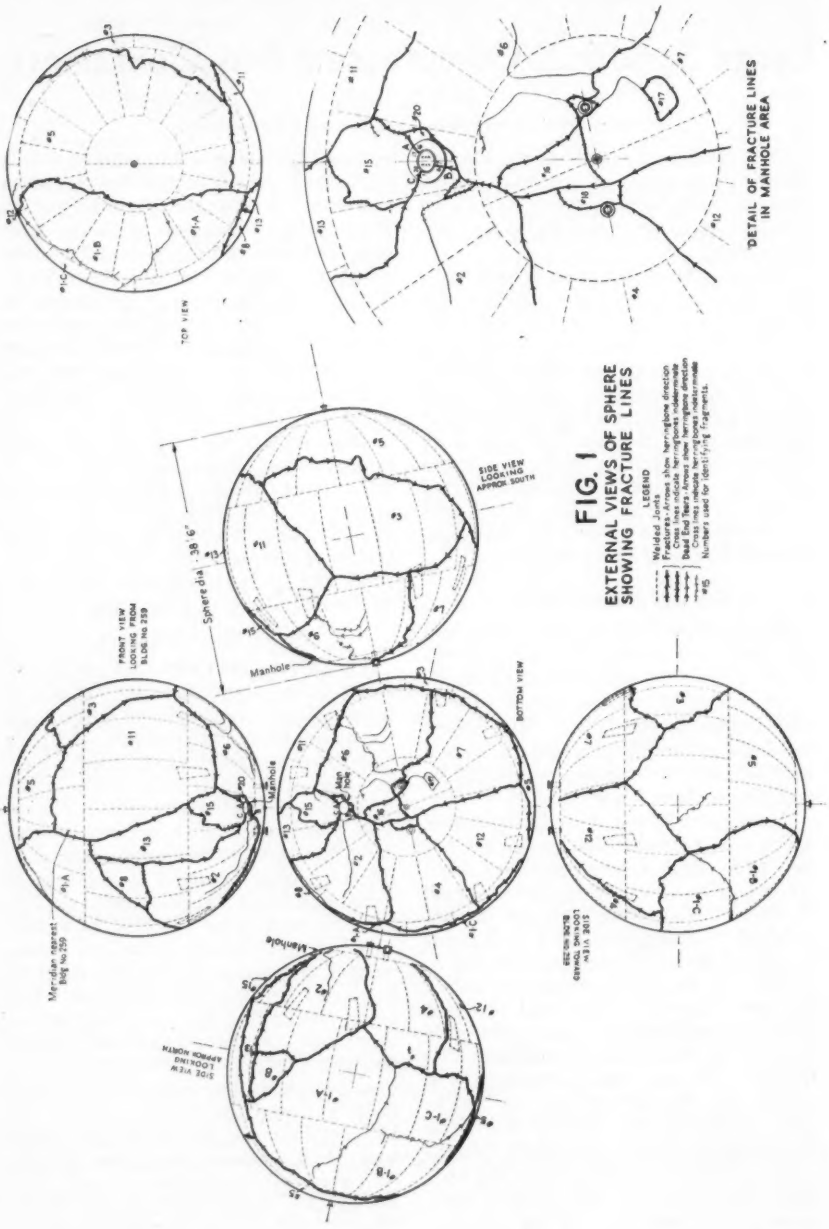

TOP VIEW
DETAIL OF FRACTURE LINES IN MANHOLE AREA
SIDE VIEW LOOKING APPROX SOUTH
Sphere dia 38' 6"
Manhole
FRONT VIEW LOOKING FROM BLDG No 259
BOTTOM VIEW
Manhole
SIDE VIEW LOOKING TOWARD BLDG No 259
Manhole
SIDE VIEW LOOKING APPROX NORTH
LEGEND
Welded Joints
Fracture lines shown herringbone direction
Cross lines indicate herringbones indeterminate
Dead End Tears Arrows show herringbone direction
Cross lines indicate herringbones indeterminate
Numbers used for identifying fragments.

FIG. 1
EXTERNAL VIEWS OF SPHERE SHOWING FRACTURE LINES

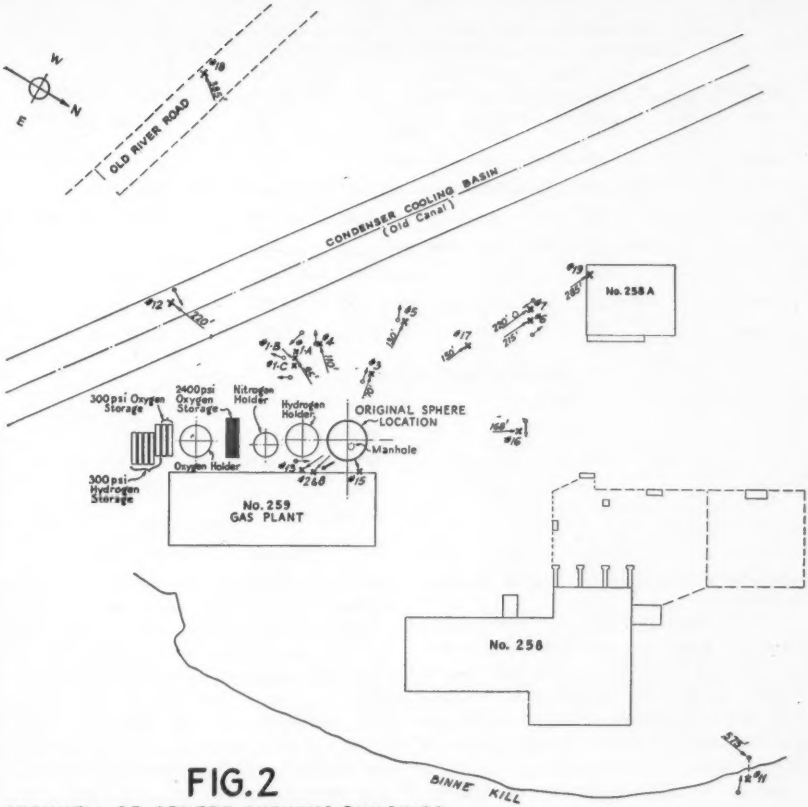

W
E
N
OLD RIVER ROAD
CONDENSER COOLING BASIN
(Old Canal)
No. 258 A
300 psi Oxygen Storage
2400 psi Oxygen Storage
Nitrogen Holder
Hydrogen Holder
ORIGINAL SPHERE LOCATION
Manhole
Oxygen Holder
300 psi Hydrogen Storage
No. 259 GAS PLANT
No. 258
BINNE KILL
0 50 100 150 200 250
SCALE - FEET
LEGEND
Indicates approximate location of each fragment upon coming to rest.
Straight line distance from center of original sphere location
(Note:- Fragment #11 slid down bank into Binne Kill.
Indicates direction of meridian welds also direction in which upper edge of fragment pointed (as placed in horton sphere).
#16 - Numbers assigned for identifying sphere fragments.

FIG. 2

VICINITY OF SPHERE SHOWING BUILDINGS AND FRAGMENT LOCATIONS

ports were tangential to the sphere. After completion, the sphere was hammer-tested while filled with air at atmospheric pressure. Later, on October 12, it was successfully subjected to an air pressure test at 62.5 p.s.i.; it was also found to be free of leaks under 50 p.s.i. air pressure when the seams were covered with soap solution. The sphere was placed in service about the middle of December, 1942; except for a few short periods it had been kept shut off.

Investigation.

The first step in the investigation was to examine the relief valves to see if the sphere might have been under an excessive pressure from the hydrogen compressor. Normal excess-pressure protection was afforded by two 2-in. relief valves which provided adequate relieving capacity. One of these, not seriously damaged by the accident, was tested with air and found to open properly at from 58 to 53 p.s.i. gage.

TABLE I

Chemical Analysis of Representative Samples From Failed Sphere
Percent by Weight

Constituents	Samples from Sphere No. 9*	No. 13*	Plate No. 2*	Sample from Manhole Neck	A.S.T.M. Requirements For A70 Firebox Grade
Carbon	0.23 0.23	0.21 0.21	0.21 0.21	.19 .19	.25 max.
Manganese	.47	.42	.43	.39	.8 "
Phosphorus	Under .020	Under .020	Under .020	Under .020	.035 "
Sulfur	.050	.026	.028	.033	.04 "
Silicon	Under .01	Under .01	Under .01	.050	
Tin	.05	.05	.05	Under .05	
Aluminum	Under .01	Under .01	Under .01	nil	
Nitrogen	.005 .006	.003	.003	.006	

*Location of Samples on Sphere

Sample No.	Zone
2, 6, 9	North Temperate
4	Antarctic & South Temperate
15	Torrid
12	Not identified
M. H. Neck	Manhole Neck

Probability of Hydrogen-Air Internal Combustion Explosion.

It first seemed that only the energy available from an internal combustion explosion of hydrogen mixed with air or oxygen could have caused such devastation, and accordingly a careful investigation was made to obtain evidence of such an explosion.

Sphere details, such as connections, cover flanges, and pressure gages on connected piping, showed no evidence of deformation other than that due to striking hard objects. The generally brittle appearance, without elongation, of the fractured edges of the fragments gave the appearance of shock such as would occur on a sudden increase in pressure; however, thick plates in vessels often fracture in this manner when tested hydrostatically to failure.

The entire operation and condition of the hydrogen system from the electrolytic cells through piping, the gasholder, and the compressor, to the sphere were checked. Purity tests were run on samples remaining in the 2000 lb., 300 lb. and the 15 lb. systems which were supplied from the same source as the sphere, and which would indicate any contamination of the hydrogen with air or oxygen that might have occurred over the service life of the sphere, but evidence was negative. The piping of the suction side of the compressor was checked by compressed air for improper cross-connections, openings and leaks, but none were found. The sphere had been purged with nitrogen before placing it in service several months before the accident, then repurged with hydrogen and brought up to pressure. Following this, satisfactory purity tests were obtained. The record of additional incoming and outgoing hydrogen from the sphere disclosed that the sphere had been mostly inactive since being placed in service and that an insufficient quantity of gas had been pumped in even if it had been pure air to account for the presence of a dangerous mixture.

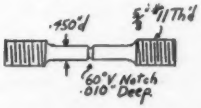
There was no obvious ignition source, since the sphere had been isolated from supply and return piping by valves closed eight hours before the accident, which valves were also found closed after the accident.

Lacking any evidence of internal combustion, the energy release in event of a sudden structural failure was then considered. Calculations were made which showed that the energy available from the expansion alone of the compressed hydro-

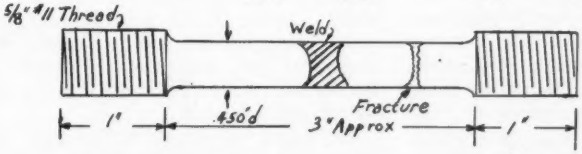
TABLE II

TENSILE AND IMPACT TESTS OF REPRESENTATIVE SAMPLES FROM FAILED SPHERE. FOR SUBNORMAL TEMPERATURES

Temperature of Sample °F.	Sample No.	Tensile Strength p.s.i.	Proportional Limit p.s.i.	Elongation in 2 in. %	Reduction in Area %	Standard Key-hole Charpy Impact ft. lbs.
A. Tensile & Impact Samples (Specimens E. G & D) From Plate						
Room Temp.	M.H. Neck	57,700	35,900	35	57	22, 19
"	2	64,400	33,000	34.4	59.1	
		63,800	28,900	35.6	59.7	25, 25, 25
"	13	64,200	34,600	30.6	58.7	29, 29, 30
		63,900	28,300	32.2	60.2	
32	2					12, 9, 11
32	13					14, 14
10	M. H. Neck					4, 6, 8
10	2	65,900		34.4	57	
		66,300		34.4	57.3	3, 4, 4
0	13	65,900		32.2	59.3	2, 2, 2
-30	M. H. Neck					2, 2, 2
"	2	67,800		33.9	57.3	
		67,000		33.3	57.3	2, 2, 2
"	13	67,600		35	59.6	2, 2, 2
		66,800		32	61.5	
B. Special Tensile Sample from Plate with 60° "V" Notch (Specimen F)						
0	13	71,000		24		



C. Special Tensile Sample through Weld between Plates (Specimen I)						
Room Temp.	4	70,900	31,400	11.0	57.1	
		70,900	31,400	10.5	55.6	



gen if applied wholly to lifting the sphere would be able to raise it 1800 ft. This amount of energy would easily have thrown all the fragments to their final resting places. In the usual terms of energy this would be about 235,000,000 ft. lbs.

Physical and Chemical Characteristics of the Steel.

At about the time it became apparent that there was no evidence in support of an internal combustion explosion, the laboratory tests on the physical and chemical analysis of the steel became available. See Tables I and II.

Samples had been cut from representative portions of the sphere plate and manhole fragments. The tests showed that the samples all conformed to the A.S.T.M. specifications for A-70 firebox grade steel both in regard to chemical analysis and physical properties at —30° as well as 70° F. and that the material was a good grade of semi-killed stock.

Another characteristic of the steel, which is not specified in the Code, is its

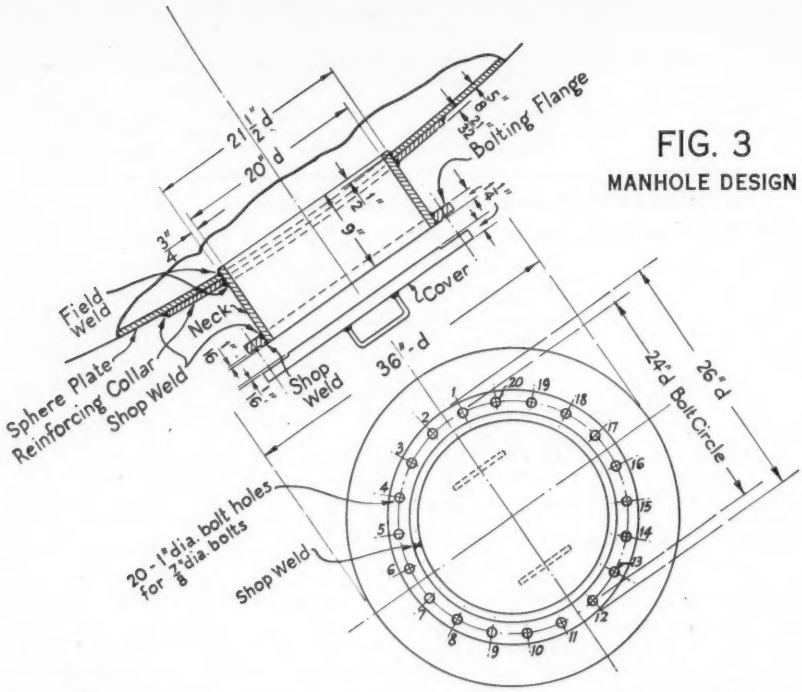


FIG. 3
MANHOLE DESIGN

brittleness when subjected to shock: first, when free of cracks, and second, in the presence of a crack or so-called notch. Unnotched impact test specimens were found to have good values in the Charpy machine at —30° as well as 70° F. and the occurrence of ductile bends in some of the fragments which struck the ground or other strong resistance at the time of the accident indicated no brittleness on being subjected to low velocity shock.

However, the impact strength of standard Charpy notched specimens fell off to a very low value when cooled only to 10° F., the temperature which prevailed at the time of the accident. See Table II. This low notched impact strength or brittleness, at a temperature corresponding to that prevailing at the time of the accident, partly explained the extensive failure into many fragments; and in addition, suggested that if a crack were present, the failure could have progressed from the bottom of an existing crack provided the sphere was subjected to only a relatively slight shock.

Location of Origin of Fracturing.

It began to appear that the rupture of the sphere was due to a structural failure and it was decided to locate, if possible, the point where the first fracture began. Each of the fragments was sketched to scale, drawing in the welded joints. A scale-model, wooden ball was then obtained and the circumferential and meridian welds, nozzles and support-leg pads were marked thereon.

By means of these welds and the sketches of the fragments all the fracture lines were placed upon the model, to scale.

Previous experience in investigating brittle failures has shown that tearing of steel plates leaves "herringbone" markings on the edges of the fractures and that these herringbones point toward the origin of the tear.

By drawing arrows on the fracture lines corresponding to the direction of the herringbones, it was established that the initial fracture was in the 20 in. diameter manhole at the inside edge of the manhole neck at Point "C."

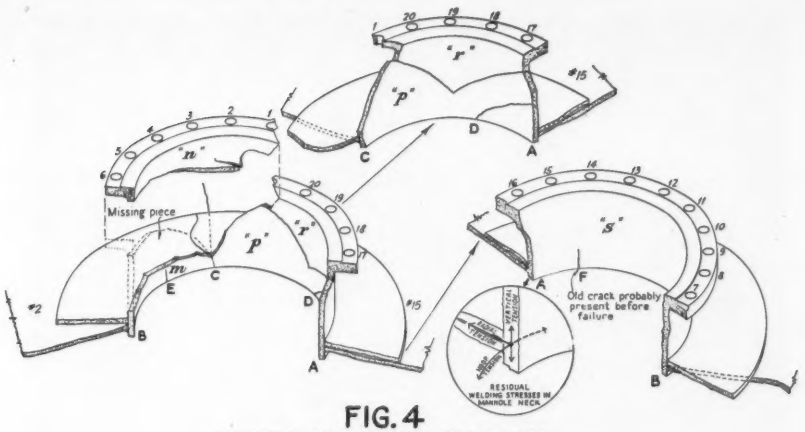


FIG. 4
LOCATION OF MANHOLE FRACTURES
FOR DETAILS SEE FIG. 4A

Comments on Weakness of Manhole. Locked-up Thermal Stresses.

Having determined that fracturing began in the manhole, this detail was carefully studied and was reconstructed, placing the fragments as closely as possible in their original positions.

The manhole consisted of a 9-in. wide by ¾-in. thick strip rolled into a 20-in. diameter neck and joined by a butt weld. At the outside edge, the cover bolting flange was joined on, using a double "U" weld. The manhole reinforcing ring, ⅝-in. thick, 21½-in. inside diameter and 36-in. outside diameter, was fillet-welded to the sphere plate around its outer edge. These welds were made in the builder's shop. During the erection of the sphere at Schenectady, the neck and bolting flange assembly was welded into the sphere plate and reinforcing ring assembly on the ground, using a very heavy weld metal deposit in the double "U" groove.

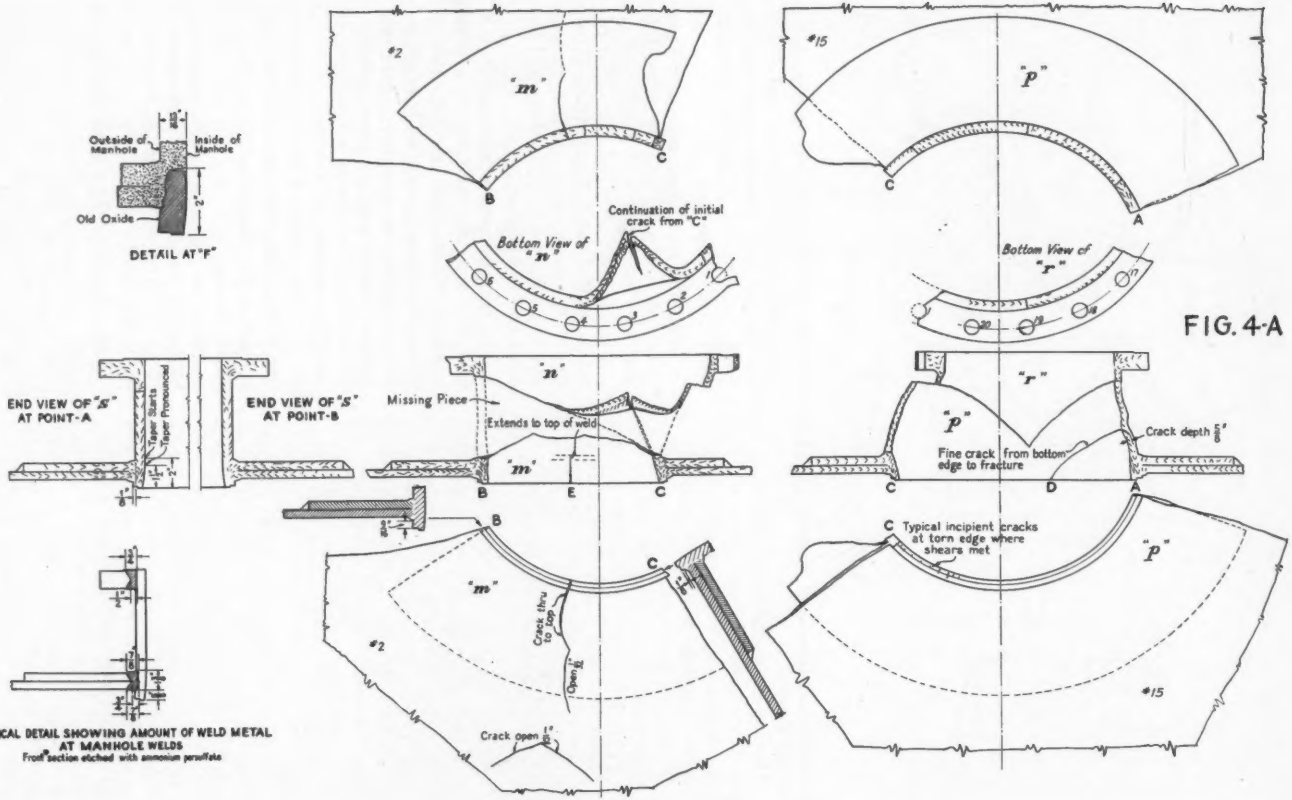
There were three main radial fractures in the manhole neck at points "A," "B" and "C," the initial fracture beginning at "C." Knowing that a crack in the manhole, however small, would afford a likely starting point, all fragments were minutely examined for similar radial cracks which had not opened up to become fractures. Three unopened cracks at "D," "E" and "F" similar to the fractures at "A," "B" and "C" were disclosed by wetting with solvent which evaporated slowly in the crack leaving a "wet line." The complete length of the cracks was determined by "magnafluxing," which consisted of spraying on magnetic powder while the fragments were placed in the field of a direct current electromagnet.

The unfinished inner edge of the manhole neck was very roughly sheared and had a 1/16-in. step with rough torn corner where the shears had met. This edge when buffed and "magnafluxed" was found to have many minute incipient cracks from 1/16 to ½ in. long and from 1/64 to 1/32 in. deep.

The large unopened cracks at "D," "E" and "F" were forced open in a testing machine. The cracks at "D" and "E" were found to be covered with a light reddish rust similar to that covering the other fractures on the plates due to exposure to the weather for about three weeks prior to careful examination. However, the crack at "F" was coated with a dark brown oxide, indicating that it had probably been present in the manhole prior to the time of the accident.

All six of the cracks and fractures are believed to have originated at the bottoms of some of the small incipient cracks in the rough sheared edge.

Past experience has shown that the circular weld joining the neck to the sphere plate, particularly with the heavy deposit of weld metal, would produce severe locked-up or residual stresses, owing to shrinkage on cooling of the metal. The


Outside of Manhole
Inside of Manhole
Old Oxide
DETAIL AT "F"
#2
"m"
B
C
Continuation of initial crack from "C"
Bottom View of "n"
#15
"p"
C
A
Bottom View of "r"
FIG. 4-A
END VIEW OF "S" AT POINT-A
Taper Starts
Taper Pronounced
END VIEW OF "S" AT POINT-B
"n"
Missing Piece
Extends to top of weld
"m"
B
E
C
"r"
"p"
Crack depth
Fine crack from bottom edge to fracture
C
D
A
B
C
"m"
Crack thru to top
Open
#2
Crack open
C Typical incipient cracks at torn edge where shears met
"p"
#15
TYPICAL DETAIL SHOWING AMOUNT OF WELD METAL AT MANHOLE WELDS
Front section etched with ammonium persulfate

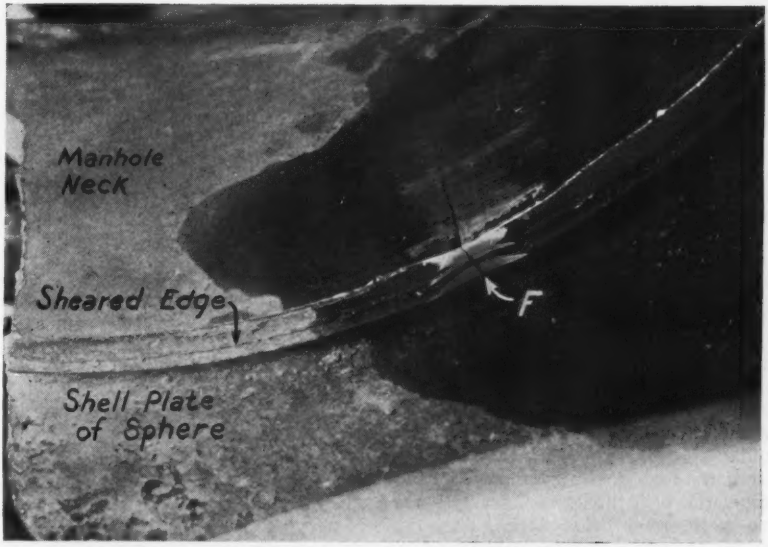


Fig. 5 (a). Old crack at "F" (Fig. 4) in inside edge of manhold neck. After buffing and magnaflux.

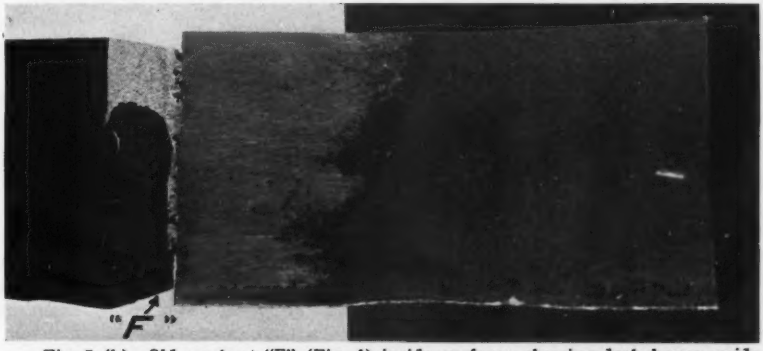


Fig. 5 (b). Old crack at "F" (Fig. 4) inside surfaces, showing dark brown oxide coating. After opening up in testing machine.

presence of such stresses and evidence of their effort to relieve themselves was attended by the deformation of the inner edge of the neck, whose diameter was about ¼ in. oversize and by the presence of the old crack at "F."

The stresses in the neck adjacent to this weld were exerted in three different directions at right angles to each other, namely: the radial tension from shrinkage of the sphere plate away from the rigid neck, vertical tension from the shrinkage of the weld metal on the outside of the neck and the normal hoop tension in the neck. Such a stress arrangement is called tri-axial and where present restricts or prevents the flow or stretching of the metal which occurs when metal is subjected to a force in only one direction. Because of this such a stress arrangement has the effect of making the metal brittle by raising the yield point to a value not safely below the ultimate strength. Under these conditions even a good grade of low carbon steel, whose ductility or yielding is expected by designers to permit self-relief, may retain locked

up stresses at values so close to the ultimate strength, that in event of even a slight shock increasing the stresses, a crack occurs.

The Cause.

The rupture of the sphere was concluded to be due to the simultaneous occurrence of a number of weaknesses, any one of which would probably not have been considered serious prior to the accident.

At 6 A.M. on the day of the accident, after the internal pressure had been raised to about 50 p.s.i., pumping was stopped and the sphere isolated by closing all valves. Following this the outdoor temperature had risen rapidly. Tests of the heating effect of the sun's rays on another similar sphere and calculations indicate that at the time of the accident, owing to temperature rise, the internal pressure was close to the relief valve opening pressure, and that the stresses due to pressure loading were probably at their highest level since the acceptance pressure test.

The presence of the many small incipient cracks in the inwardly projecting, free, edge of the neck, the severe residual shrinkage stresses arranged triaxially in the neck adjacent to the weld and the higher stress level in the sphere plate adjacent to the manhole, owing to the redistribution of stresses due to the large opening, resulted in a condition favoring crack formation. It is therefore likely that the three main radial fractures in the manhole neck had their origin at the incipient cracks in the unfinished edge and it is probable that one of these incipient cracks had, at the time of the accident, developed into a crack comparable in extent to the one found with the dark brown oxide coating and was the trigger setting off the rapid progressive failure under the brittle plate conditions.

The possibility that the sphere might have been subjected to some external shock, either maliciously or accidentally was given careful consideration, but no evidence of any such occurrence could be found.

Conclusions.

The character of this failure was due mostly to the brittleness, under the conditions existing at the time, of the steel plates from which the sphere was constructed. Such brittleness, as shown by the notched impact tests of the steel at corresponding temperatures, combined with stresses of a character (multi-axial) which restrict ductility and favor a brittle type of fracture, brought about a characteristic fragmentation or a rupture into a considerable number of pieces with the fractures showing little evidence of the reduction in area or shear which would be present with a simple tension failure. Much more extensive fracturing of this type can occur from the expenditure of a given amount of energy than if the breaks were of the more frequently experienced uni-directional tension type occurring in plate of normal characteristics.

Failure by extensive fragmentation may give an impression of the existence of energy unusual in character or amount, but such is not necessarily the case. With the great amount of total energy stored in compressed gas and with its potentially rapid rate of release, complete rupturing of some type may result. The damage to surroundings is a consequence of the liberation of great energy rather than of the type of fracture of the container.

Neither a low value of notched impact resistance nor the existence of multi-axial stresses reduces the actual ultimate tensile strength of the steel. However, the former leads to the occurrence or spread of fractures under exposure to shock while under stress, whereas the same stress and shock conditions would not produce such extensive fracturing in the case of a more ductile steel. The latter condition, by diminishing the ductile flow of metal, has the effect of raising the yield point to values approaching the ultimate strength, thereby interfering with a reduction of high local stresses by stretching in the vicinity. If stresses up to the yielding point have occurred as a result of the welding, they will remain at a value not safely below the ultimate strength. A relatively small additional stress or shock can then produce a failure.

These factors, the seriousness of which cannot be accurately predetermined by methods now available, make it important that in the design of structures which have considerable energy available for self-destruction and serious external damage, the metal be of good ductility, and also

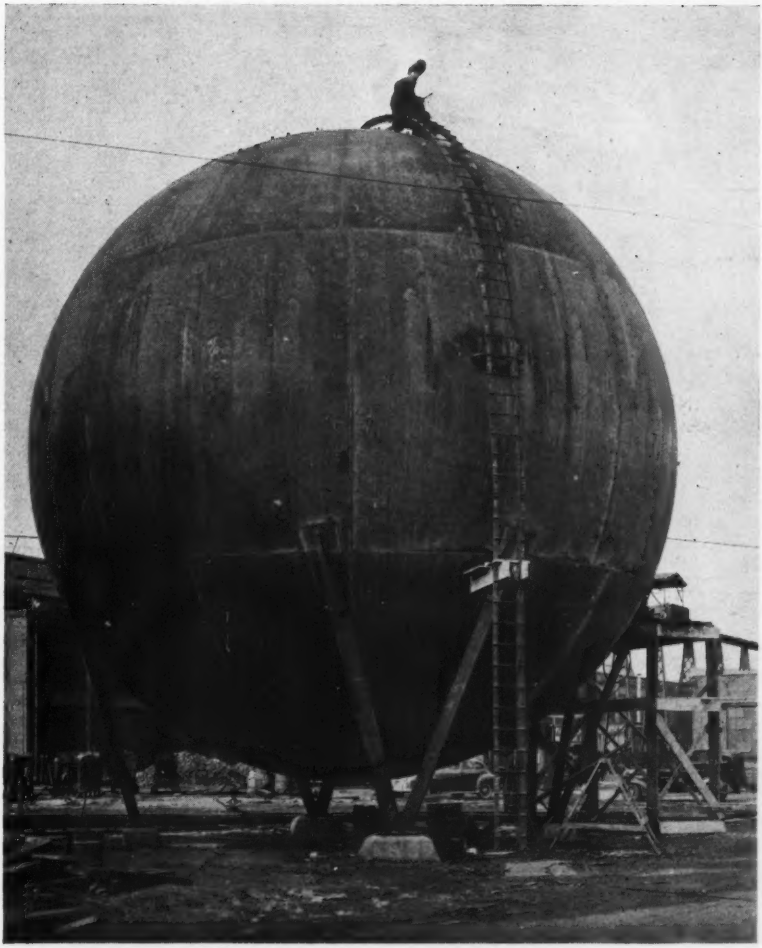


Fig. 6. Sphere similar to the one that failed.

that indeterminate high local stresses produced by fabrication or by poor distribution of working stresses be eliminated, or at least minimized, by all practical measures.

This accident demonstrates that the use of steel having a low notched impact value at winter temperature favors the development and progress of the failure. It therefore seems a sound move in a practical direction, when constructing vessels of this type, to call for steel having a good notched impact value at the minimum temperature to be anticipated at the location of the vessel. This can be attained by including in specifications a notched impact strength requirement such as 15 ft. lb. for standard Charpy Keyhole Specimen 0.4 in. x 0.4 in. at the required temperature. This is now under active consideration by the A.S.M.E. Boiler Code Committee. Minimum probable temperatures can be determined from U. S. Weather Bureau records taken at the nearest station.

In an un-stress-relieved pressure container, residual stresses of uncertain mag-

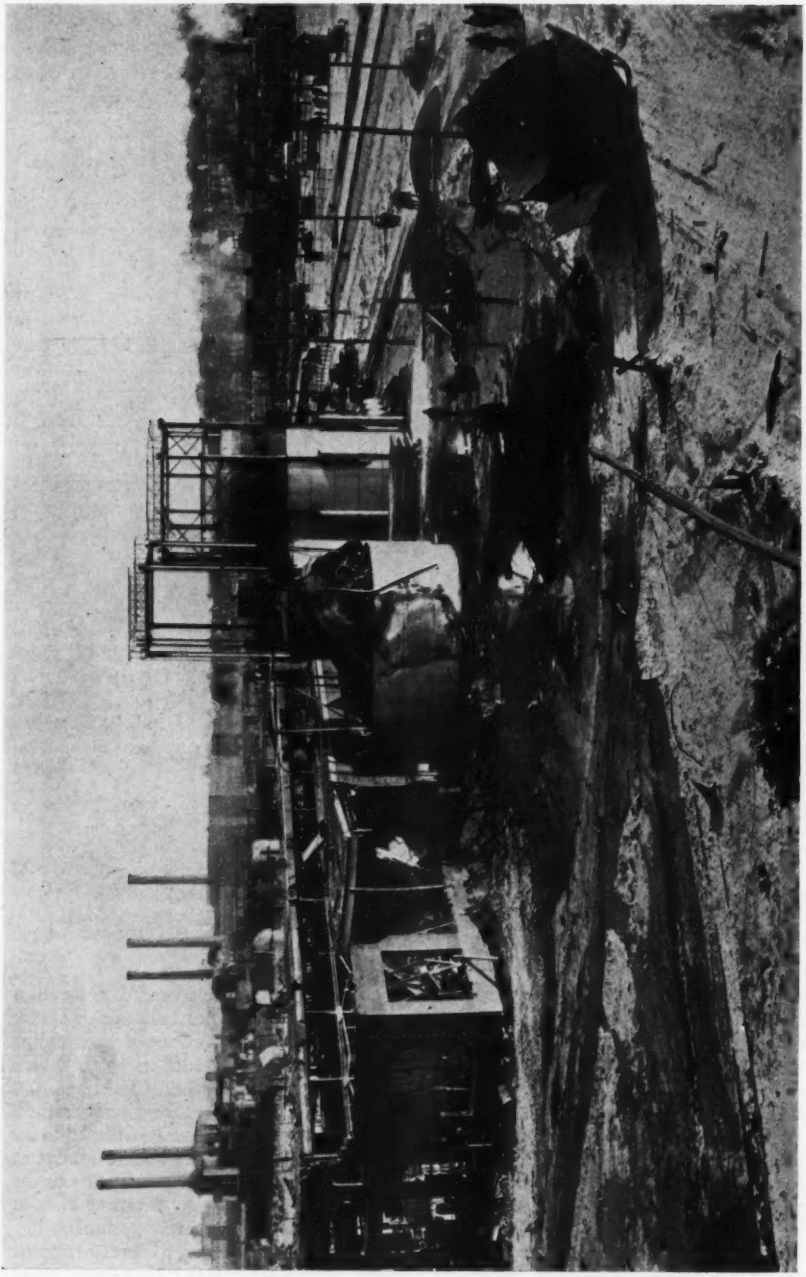


Fig. 7. Damage after explosion.

Fig. 8 (a). Sample from another accident.

Fig. 8 (b). Sample from failed sphere. Typical "herringbones" on fracture edges. Arrows formed point toward origin of tear.

nitude can remain after welding, especially at points of complicated stress arrangement. This possibility exists even with the best quality of welding, carefully developed welding procedure, and the use of high-grade, ductile base metal. Even though experience has shown that only a very few such structures have failed, the extreme danger to life and property emphasizes the importance of avoiding high residual stresses by methods of proved effectiveness.

Because vessels of this class for the storage of gas are not required to be constructed or supported to carry a liquid load they are not required to be given a hydrostatic pressure test. Also, owing to the serious consequences of failure of a gas container under pressure, as demonstrated in this case, a maximum air test pressure of only 1¼ times the working pressure is called for by the A.S.M.E. Code. Such a test was applied to this sphere following its completion. Its value in disclosing defects which are serious structurally or in contributing materially to stress-relief, may well be questioned in view of the proportionally larger variables introduced by

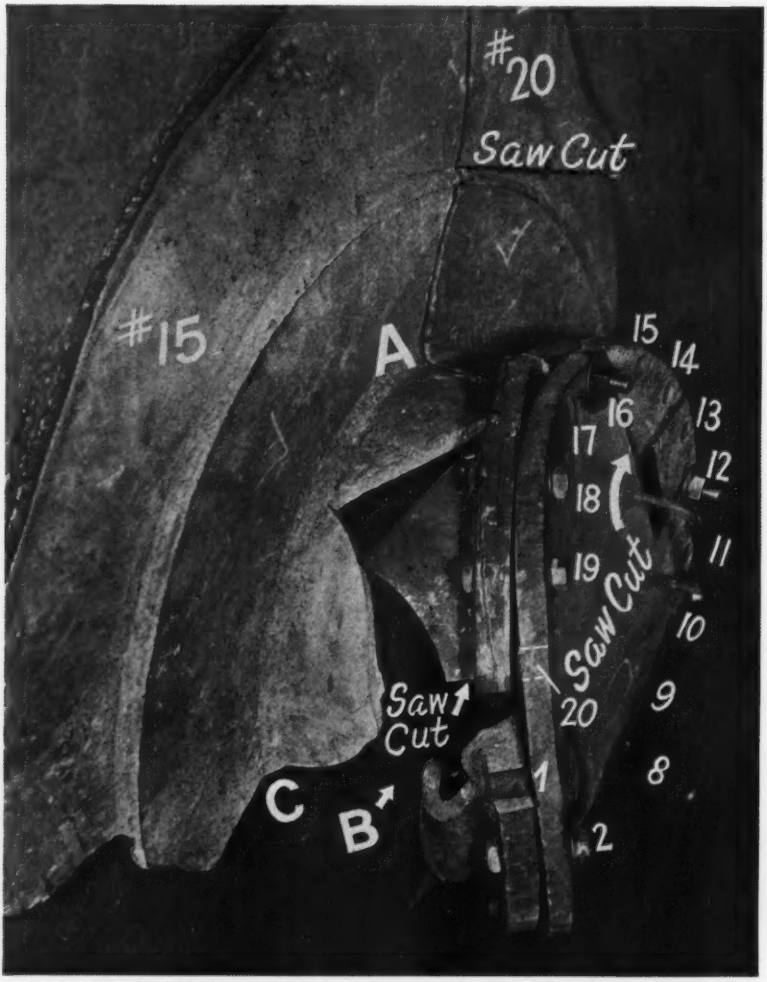


Fig. 9. Double bend in manhole cover. Reassembly of fragments excepting No. 2.

working conditions. Obviously its adequacy is not comparable with the generally advised and accepted hydraulic test at double the working pressure. Despite the increased cost over vessels not tested in this way there is no apparent sound reason for accepting an uncertain low factor of strength in this hazardous type of equipment. It seems advisable, in the interest of greater certainty in safety, that welded pressure vessels to contain gas or liquefied gas under pressure appreciably above atmospheric, such as in excess of 15 p.s.i. gage, be designed to support a full water load and be tested hydrostatically under double maximum working pressure.

Manholes should be designed so that weld metal will be deposited where complex or multi-axial stresses will be avoided as far as possible. Reinforcement around manholes or other large openings should be designed and fabricated in conjunction with the manhole to give a unit which will redistribute safely the stresses which

would otherwise be carried by the shell of the vessel.

All welds at manholes, pipe connections and at the point of attachment of supports should preferably be made in the builder's shop. Following this, the assembly consisting of the detail and the plate to which it is attached should be stress-relieved by drawing in a furnace. Finally, the above sub-assemblies should be treated with magnetic substance and magnetized (magnafluxed) in order to detect cracks. It is possible that some other effective procedure to provide the same security can be developed.

The inside edge of manhole necks and other nozzle connections, or similar parts, should be finished smooth so as to remove all surface cracks. Absence of cracks should then be checked by magnaflux treatment.

Piping connected to a sphere should be designed with sufficient flexibility to prevent transmission of shock or stress to the shell.

In the case of tanks already erected and having manholes of a design similar to that involved in this accident, the minimum additional attention which should be given to checking potential weakness is, at the earliest time convenient for releasing pressure and, if necessary for safety, purging the vessel with inert gas or air, to magnaflux the entire manhole region. If any cracks are disclosed, the plate containing the manhole should be cut out and carefully replaced by a manhole and plate sub-assembly made in accordance with the preceding paragraph. However, if the cracks are small and can be removed by grinding without impairing the strength of the structure they may be so removed.

Tulsa Hangar Fire.

By Captain H. E. Kezer, A.C.,
Secretary, N.F.P.A. Committee on Aircraft Fire Fighting.

A fire in a large hangar of the Douglas Aircraft Company at Tulsa on May 9, 1944, presents a number of important lessons in fire protection which should be of interest to N.F.P.A. members. The Army Air Forces has accordingly released certain information on this fire for publication in the QUARTERLY with the thought that the experience in this fire may be helpful in preventing similar losses elsewhere.

The section of the hangar where the fire occurred was 200 feet wide by 425 feet long, with an area of about two acres. The hangar was 65 feet high to the roof, 40 feet to the lower chords of the roof trusses. Another similar section, cut off by a fire wall, was not involved in the fire. The hangar was of unprotected steel construction, with a steel deck roof insulated with spun glass roof insulation and covered with the usual tar and gravel roof surface. A considerable area of the structure was severely damaged by heat. The plane where the fire originated was practically destroyed; other planes were wheeled out of the hangar safely.

The building was fully protected with eight deluge type automatic sprinkler systems, with a total of 1060 open sprinkler heads arranged with standard control equipment actuated by thermostatic devices located below the roof and also provided with manual controls. The water supply was designed for the simultaneous operation of not more than three or four of the eight systems. When the fire occurred all eight of the deluge valves were tripped. The water supply proved inadequate and the sprinklers were largely ineffective in controlling the fire and protecting the exposed structural steel members. The result of the manual operation of the valves of the system beyond the fire was comparable to the manual closing of sprinkler valves in other fires where sprinkler systems have been ineffective because the water was shut off.

Cause of the Fire.

On the evening of the fire a "pick-up" crew was making final adjustments on a B-24 bomber. The plane would have been ready for flight at 7:00 A.M. the following morning.

A mechanic undertook to tighten an electrical connection with a screw driver. The wiring system of the airplane was energized from a 28-volt D.C. portable

The remains of the B-24.

generator plugged into the power receptacle on the side of the fuselage. Several aluminum tube hydraulic lines carrying hydraulic fluid to the ship's controls pass within a few inches of the electrical connection which was being tightened. The hydraulic fluid is a flammable liquid with an alcohol base and is under a pressure of approximately 1000 lbs. per sq. in. in the hydraulic lines. While the mechanic was tightening the electrical connection his screw driver made a contact with one of the hydraulic lines, causing a short circuit which burned a hole in the hydraulic line and ignited the hydraulic fluid which was released. The burning fluid sprayed over the interior of the bomb bay section.

The mechanics escaped immediately through the bomb bay, but the burning liquid had covered the upper part of one mechanic's body and the left side of the other mechanic's face. After one mechanic escaped from the bomb bay, the supervisor of field operations smothered the flames about his head with a coat. He was taken to the hospital with second degree burns. His condition is not considered serious. The other mechanic received first degree burns on the face which required only first aid treatment.

The pressure in the hydraulic lines is maintained by an automatic electric driven pump in the bomb bay section. The fluid is pumped from a 6½-gallon reservoir. This pump continued to operate intermittently during the early stages of the fire and discharged additional quantities of the flammable hydraulic fluid. Had the external power been disconnected immediately after the start of the fire, extinguishment could probably have been effected with hand extinguishers.

There was approximately 1200 gallons of gasoline in the main wing fuel tanks at the time of the fire. The fuel lines from these tanks, consisting of ¾-inch rubber hose, pass through the upper part of the bomb bay section, one such fuel line being about 18 inches above the point where the fire originated. With the intense fire caused by the burning of the hydraulic fluid, it was but a very short time until the fuel lines burned through, releasing the gasoline from the fuel tanks.

The flames and intense heat reached the hangar roof, severely warping the steel trusses over the fire and igniting the tar paper backing of the spun glass insulation and the tar of the built-up roof. The fire in the tar paper and tar of the roof was

stubborn and difficult to combat with hose lines.

Fire Fighting Operations.

The first alarm of the fire was received in the plant fire alarm office and in the plant fire station at 8:39 P.M. from a manual fire alarm box. The fire captain on duty and three men proceeded immediately to the scene of the fire with a pumper. It is probable that the apparatus arrived within two minutes after the alarm.

Upon his arrival, the fire captain noticed that none of the deluge sprinklers were in operation. He immediately proceeded to the riser of the deluge sprinkler system immediately south of the site of the fire, and tripped this system with the manual pull handle. He advised that this was the only system that he operated manually. Almost simultaneously with the operation of this system the system directly above the fire operated automatically. Two minutes later another adjoining deluge system operated automatically. With only these three systems in operation the fire should have been controlled without difficulty. However, within the next five minutes the other fire systems were operated manually, and all eight systems continued in operation until 11:05 P.M.

Truck No. 1 from the plant fire department was the first to respond and laid two 2½-inch hose lines from two hydrants on the west side of the hangar. Two booster lines with fog nozzles and one 1½-inch line with a hip pack foam nozzle were immediately placed in service from this apparatus.

After arrival at the fire, the fire captain immediately called for the crash truck and two ¾-inch lines were used with high pressure fog foam. Truck No. 2, a salvage service truck with a bank of six 50-pound cylinders of CO_2 arrived with the crash truck and the 300 pounds of carbon dioxide were used without success. At about 9:30 P.M. a call was sent to Hangar No. 6, Air Transport Command, and another crash truck was dispatched and two ¾-inch lines with hip pack foam nozzles were placed in service. At about 9:45 P.M. the 500 g.p.m. pumper and the Class 125 crash truck were called from the Modification Center. The pumper took suction from the hydrant at the northeast corner of the hangar and two lines were taken to the roof. Two ¾-inch lines with hip pack foam nozzles were used from the crash truck. A call was made to the Tulsa Fire Department at 9:33 and they responded in about 15 minutes with an aerial ladder which was used to take lines to the roof.

The fire was considered to be under control at 11:30 P.M. and completely extinguished at 2:35 A.M.

Conclusions.

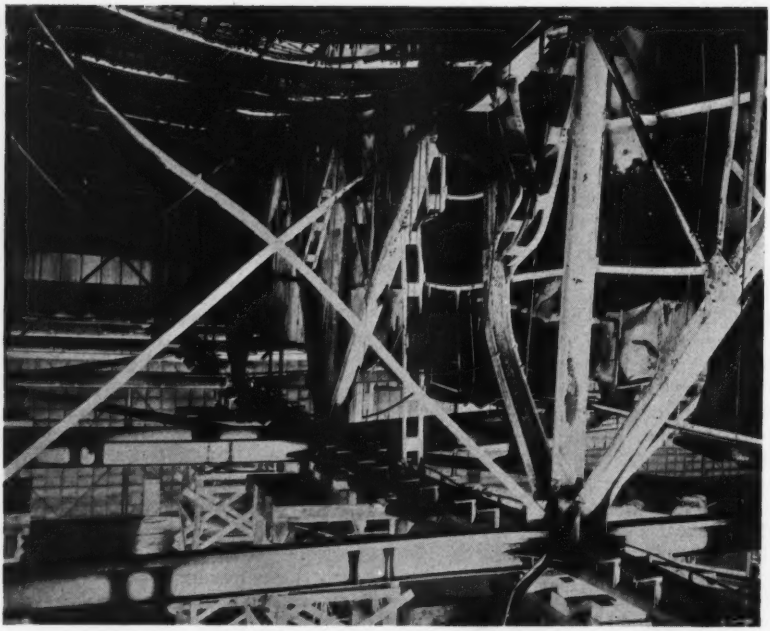
The fire destroyed the plane, except for the wing tips and a portion of the tail. The manual efforts of the fire department in confining the fire in the vicinity of the plane in which it originated, appear to have been satisfactory. No fire spread on the water to other sections of the hangar.

The steel trusses, the spun glass roof insulation, supporting purlins and expanded metal, steel roof decking and tar and gravel roof covering in the bays over the fire for nearly the full width of the building were badly damaged by heat. This damage was the definite result of insufficient water from a sprinkler system for adequate cooling, and indicates a temperature of approximately 900° to 1000° F.

Water supplies available from the three 1500-gallon, 100-pound fire pumps and the strong city water system are basically adequate for any reasonable demand from sprinklers and hose streams that might be anticipated under the conditions of intelligent fighting of a fire such as the one which occurred.

This fire was the result of failure to observe the pertinent regulation, which states in part, "When possible, the electrical system of the airplane should be de-energized by disconnecting the power supply or by turning off the main switch while work is being performed on the electrical circuits, electrical equipment or locations where the work may create short circuits. If it is necessary to keep the electrical system energized while work is being performed on an air electrical circuit or equipment, the individual circuit where the work is being performed should be de-energized by turning off the switches controlling such circuits."

Operation of the 1060 sprinklers on the eight deluge sprinkler systems, in addition



Damage to the roof trusses and roof.

to the hose streams, placed a draft on the water supply 2½ to 3 times that which would be anticipated and resulted in such a reduction in pressure as to preclude effective distribution from the sprinkler heads. The pressure at the yard level has been determined to have been not in excess of 40 lbs. per sq. in. during the period of the fire, which is totally inadequate to supply the sprinklers in this hangar.

The basic mistake in the operation of the fire protective equipment was the manual operation of those deluge systems which were outside of the fire area, followed by permitting these to operate throughout the fire.

The damage to the plane, subjected as it was to an intense internal fire created by the hydraulic oil flame, fed with gasoline in large quantity and aggravated by oxygen released from the oxygen bottle, would undoubtedly have been considerable, but building damage could have been expected to be minor or non-existent if full advantage had been taken of the available fixed and mobile fire protective equipment.

A determination of the value of fire curtains between deluge systems, as provided in this instance, cannot accurately be made because of the convincing evidence that those systems outside of the vicinity of the fire area were operated manually rather than automatically by the heat of the fire. The experience, however, gave no indication that the fire curtains would not have been effective.

This officer is convinced that had the deluge systems been allowed to operate as heat conditions demanded, probably three or at the most four would have functioned. This number of systems supplied with adequate water, as would have been the case, would have insured proper distribution and prevented damage to the roof, possibly reduced damage to the plane. It is believed that with the aid of hose streams, the fire would have been confined to the plane in which it started, and it would have been unnecessary to remove the other planes which were in the hangar.

More Bowling Alley Fires.

Since the publication of the article in the April QUARTERLY entitled "Recent Bowling Alley Fires" (also available in pamphlet reprint form), serious bowling alley fires have continued and there have been many inquiries from N.F.P.A. members as to effective precautionary measures. We are presenting herewith reports of typical bowling alley fires which have been reported to the N.F.P.A. Department of Fire Record since the publication of the April QUARTERLY. These represent only a fraction of the total number which have occurred. A prominent manufacturer of bowling alley equipment reports that through a survey of 11,300 bowling alley establishments in the United States he has reports of 75 fires which have occurred in the past two years. These fires have ranged all the way from negligible individual losses to total losses. On a statistical basis, the number of bowling alley fires in comparison to the total number of bowling alley establishments is perhaps not serious, but the large number of individual heavy losses has focused the attention of the fire protection fraternity on the problem of bowling alley fire-safety, and owing to the practical difficulties under war conditions of rebuilding bowling alleys which have been damaged or destroyed by fire, the operators are generally interested in taking all possible precautionary measures.

In the article in the April QUARTERLY emphasis was placed upon the hazard of the use of pyroxylin lacquers for refinishing pins and alleys. Several of the fire reports presented in the April issue stressed the use of pyroxylin lacquers as a major contributing cause of the loss. The widespread increase in the use of pyroxylin lacquers for this purpose having been coincident with the increased number and seriousness of bowling alley fires, it has been natural to assume that there has been a connection between the use of lacquers and the fire severity and frequency. The more recent fire reports, however, indicate that while the use of pyroxylin lacquers has been a factor, this does not by any means constitute the sole or principal hazard; the record clearly shows that improper construction, poor housekeeping, careless smoking, lack of adequate fire protective equipment, substandard heating, ventilating and air conditioning systems, and similar common features of fire hazard were present in practically all of the cases reported.

In one of the fires reported in the April QUARTERLY specific mention was made of the use of a lacquer sold under the trade name of Mineralastic.* We have been advised that recently fire protection authorities have in many instances prohibited the use of Mineralastic. We regret having mentioned the trade name of an individual product, as this product is no more hazardous than various other pyroxylin lacquers and we strongly advise that all measures taken towards eliminating or minimizing the hazards due to the use of pyroxylin lacquers should be applied to all materials in this class. The regulations for bowling alleys issued by the Fire Prevention Bureau of the Cleveland Fire Department as quoted in the article in the April QUARTERLY do not prohibit the use of pyroxylin lacquers; the prohibition reported in the QUARTERLY was only of a temporary nature, pending the promulgation of the regulations given in the previous article.

As is the case in many other classes of property it may not be practicable to eliminate completely all potential fire hazards. As shown by the record, for example, smoking is particularly difficult to curb in bowling alley properties. However, it is possible to provide fire protection adequate to neutralize these occupancy fire hazards by the installation of automatic sprinkler protection. This is shown in conclusive fashion by the N.F.P.A. fire record of bowling alleys for the past five years. Twenty fires in non-sprinklered alleys for which detailed loss figures were reported totaled $2,681,461 loss, or $134,073 per fire. During the same period there were 14 fires in sprinklered alleys.

Disregarding one loss of $150,000, which resulted when an unknown person

*The original composition of this material has been modified. See p. 72.

shut off a sprinkler system, the average loss in sprinklered bowling alley fires reported to the N.F.P.A. has been only $1,172, or less than one per cent of the average loss in non-sprinklered bowling alleys. As is well known to the fire protection profession, sprinklers are on the job day and night, they do not depend upon manual discovery before they go into action, and they are not driven from the building by smoke as were the firemen who attempted to fight one $300,000 bowling alley fire reported in this record. Sprinklers are advisable protection for existing bowling alleys as well as for newer alleys that may be erected.

The National Board of Fire Underwriters in June, 1944, prepared a pamphlet entitled "The Fire Hazard of Bowling Alley Establishments" which gives their comments on the use of pyroxylin and other finishes with flammable solvents and also gives specific recommendations for the safeguarding of bowling alley establishments. We are printing extracts from this material on page 71 so that it may be readily available to N.F.P.A. members for reference. (The pamphlet may be obtained on request from the National Board of Fire Underwriters, 85 John Street, New York.)

Typical Bowling Alley Fires Reported to the N.F.P.A.

(Supplementing list published in "Recent Bowling Alley Fires," April, 1944, Quarterly)

January 9, 1944. Pladium Bowling Lanes, Houston, Texas.

This was a 1-story bowling alley building of brick veneer construction, 50 by 150 feet in area. Fire was discovered in a rear locker room by employees. The alarm was considerably delayed while employees attempted to extinguish burning cushions and clothing, using chemical extinguishers. According to a report by the Fire Department, the fire started from a gas hot plate which ignited a coat and a bench. An alarm was telephoned to the fire department at 4:51 P.M., but by the time firemen arrived it was impossible to enter the building. The only openings were the double front doors and a small rear door, until the roof and north and south walls collapsed, making it possible to apply water from 13 hose streams on the heart of this fire. A frame garage 30 feet away was damaged by the fire. The loss has been variously estimated at $115,000 to $150,000.

January 21, 1944. Health Center Bowling Alleys, Richmond, Va.

This bowling alley establishment of brick-joisted construction was totally destroyed by a fire which started in a stockroom in the rear of the building. Further details not reported.

January 24, 1944. Jefferson Bowling Alleys, Buffalo, N. Y.

Fire started in the pin refinishing room in the basement of this brick-joisted building. Pins were being treated in a "pin rejuvenator," when a spark from the machine caused lacquer solvent vapors to explode. The fire extended to a meat market and food shop on the first floor of the building and these were completely destroyed.

February 10, 1944. Amos Bowling Center, Syracuse, N. Y.

Fire started in a pin refinishing room supposedly due either to a spark from a pin machine or due to careless smoking. The pin room was cut off from the main building, with the opening protected by a fire door which prevented the spread of the fire to the main area. Loss slight.

February 20, 1944. Forsyth Bowling Center, Winston-Salem, N. C.

Fire reported due to a defective furnace in a brick-joisted bowling alley building caused 50% damage to the alleys and slight damage to the building.

February 24, 1944. The Boston Recreation Company, Boston, Mass.

Fire occurred in the bowling alley section on the sixth floor of a brick-joisted building housing a restaurant on the first floor, with pool-room and bowling alleys above. Fire started among some old candle pins stored at the rear of the alleys and was believed due to careless disposal of a lighted cigarette. An employee telephoned the alarm, while other employees used chemical extinguishers which brought the fire under control. One automatic sprinkler head operated and completed extinguishment. Loss: $900.

February 27, 1944. Tick Tock Inn, West Coxsackie, N. Y.

A frame building in the rear of this inn contained bowling alleys. Fire started in the roof of the main building of the inn. This country inn lacked any adequate supply of water for

Montreal Gazette.

Loss estimated at $300,000 or more resulted when fire destroyed the Academy Bowling Alleys in Montreal and damaged near-by structures.

fire fighting and the fire soon spread beyond control, involving the alley building, which was a total loss.

March 5, 1944. Group Fire, Brockport, N. Y.

Fire which started in the office of a garage and automobile sales building when the owner tried to relight a defective oil heater, spread to bowling alleys in an adjoining building. The alarm was delayed while the owner of the garage attempted to control the fire with an unapproved extinguisher. The buildings were of one-story frame construction. Twelve fire department hose streams were employed to prevent further extension of the fire. Total loss from fire: $57,000.

March 9, 1944. St. Patrick's Parish Building, Jersey City, N. J.

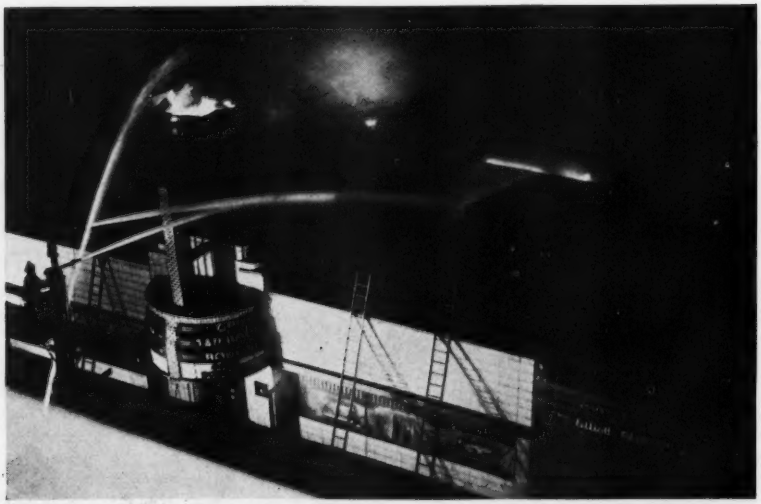
Four bowling alleys in the basement of the parish building were damaged by a fire blamed on a cigarette. The loss was not reported.

March 10, 1944. Hertel Bowling Academy, Buffalo, N. Y.

Fire originated in basement boiler room and spread up open partitions to attic over bowling alleys on the second floor. The fire department was forced to pull down the ceiling over bowling alley to control blaze. There were no sprinklers in this brick-joisted building. Salvage operations by the fire department limited the water damage. Finishing of bowling pins in this location had been discontinued and was not a factor in the fire. Loss: $11,693.

April 8, 1944. Twentieth Century Recreation Building, Grand Rapids, Mich.

Fire started in bowling alleys on the second floor of this three-story brick-joisted recreation building. The fire department has been unable to determine the cause of the blaze, which was discovered by an employee reporting for work at 5:30 A.M. It is said that the alleys had been refinished with lacquer three weeks before the fire, but there was no specific indication that this had any important bearing on the fire. When the building was remodeled for bowling alley and billiard room occupancy, the automatic sprinkler system had been removed from the second floor "to protect the bowling alleys from possible water damage." When this fire occurred a number of heads on the first floor operated, but due to lack of sprinklers above, the flames spread throughout the second floor and involved the entire upper part of the building. The fire department used 20 lines of 2½ and 3-inch hose supplying deluge appliances, deck nozzles, and a water tower. Chief Fire Marshal Edward C. Palmer comments, "I think bowling alleys should have sprinkler protection." Loss: $90,000.



International.

Before more than one hose stream could be placed in operation firemen were driven from the Playdium Bowling Alleys in Chicago. Flames are shown breaking through the roofspace over the alleys. The fire was virtually inaccessible to fire fighters, due to the large area and lack of suitable openings for attacking the blaze.

April 17, 1944. Montreal Bowling Academy, Montreal, Que.

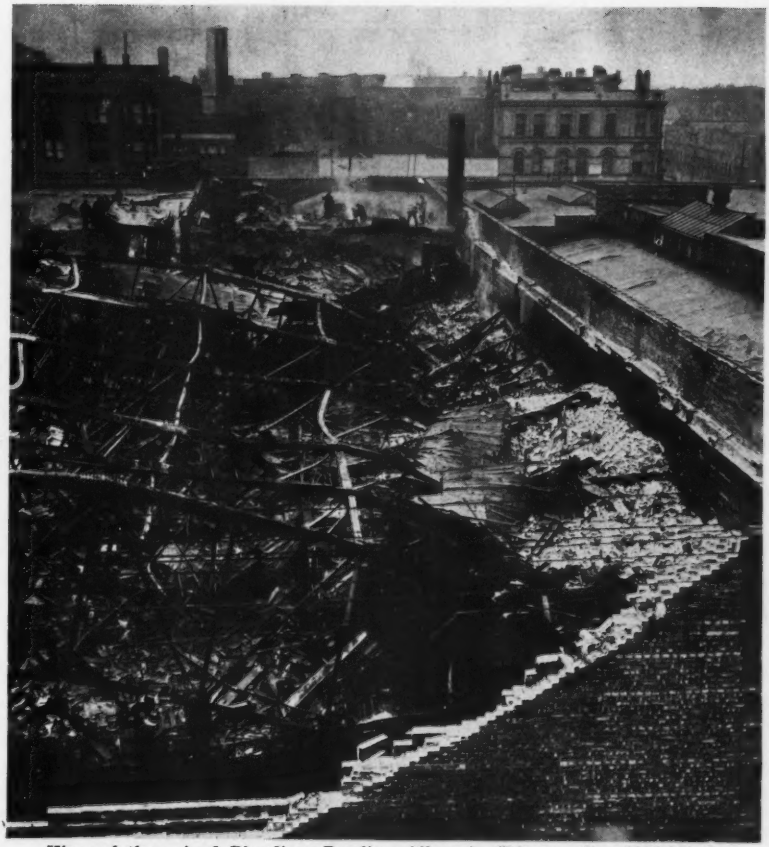
A 4-story brick and stone, joisted building housing the city's largest bowling center was completely destroyed by a fire which also razed the adjoining Paris Café, and heavily damaged seven other business establishments, as well as seriously damaging the façade and show windows of Dupuis Frères' Department Store across St. Catherine Street. The fire, reported at 5:55 A.M. on a Sunday, started on the third floor from an unknown cause. The fire department reports that a smoke explosion caused the fire to spread all over the building and to adjoining buildings. Newspaper comment indicated that "oils and wax used in the preparation of the bowling alleys were believed responsible for the fierceness of the fire." Some 33 hose streams were used to attack the fire from all sides of the building, as well as from ladders and adjoining roofs. There were no sprinklers. The loss has been estimated between $300,000 and $500,000.

April 21, 1944. Playdium Bowling Alleys, Chicago, Ill.

This bowling alley structure was erected in 1939 and housed 32 bowling alleys. The main section of the building, not including a game room and office, covered an area of 150 feet by 250 feet. Walls were of brick and hollow tile. The roof was of tar and gravel on wood, supported by unprotected steel trusses and columns. The lower flanges of steel truss supported a wire lath and plaster ceiling nailed to 2 x 6-inch wood joists, with 1½ inch of insulation, forming a concealed space 3 to 10 feet high. Air conditioning and heating ducts were installed in the concealed space. The air conditioning unit was located in the basement boiler room. There were two large exhaust blowers on the roof, used for exhausting hot air from the concealed space and also for venting the bowling alley through louvered vents directly into the roof space. The main floor was of concrete. There were no automatic sprinklers.

The bowling alleys extended across the width of the building with the pits along one side wall. There was a balcony over the pits, 36 inches above the main floor level. This balcony, about 180 feet long, housed a pin and lacquer room, a storage and mixing room, and a room for the pin boys. At the front of the building an entrance corridor some 60 feet long led into the main area located in the rear of several stores and a tap room. Locker rooms were located in a partial basement.

Shortly after 1:30 A.M. the owner and assistant manager discovered smoke coming down through the vents in the ceiling. The owner requested the patrons of both the bowling alley and cocktail lounge to leave the premises immediately without first securing their personal effects. At the same time the desk man took an extinguisher and ran back to the pin storage room, on the balcony above the pits. On arrival he found smoke coming from the pin and lac-



View of the ruined Playdium Bowling Alleys in Chicago after $300,000 fire on April 21. Failure to segregate areas where flammable finishing processes were carried out was chiefly responsible for this large loss. The property was not equipped with automatic sprinklers.

quer storage room, which was enclosed with celotex on wood studding, with an ordinary wood panel door. Finding the door locked, he retraced his steps to obtain the key. On return he found the door of the room blown out, presumably from hot gases.

The first alarm was telephoned to the fire department at 1:39 A.M. This was followed during the next hour by six subsequent calls for more equipment. The first two engine companies to arrive worked a stream from the center of the building. Before a second line could be charged, fire started to drop down into the pits and the building filled with smoke, forcing the firemen outside. The fire was then fought from the outside, using fifteen streams, including several from turret pipes and a water tower. The roof collapsed ten minutes after the arrival of the first companies.

Failure to control this fire is attributed to delayed alarm, large unbroken area of combustible construction (37,500 square feet), and large quantities of flammable liquids used for processing bowling pins. The pin refinishing room was not properly located, was not cut off, was without proper ventilation for hazardous locations, and contained ordinary lights, switches and motors.

The total loss, including use and occupancy, was approximately $300,000.

May 21, 1944. Business Building, including Bowling Alley, New Glasgow, N. S.

Fire discovered at 3:50 A.M. Sunday morning started in the basement of a two-story frame building housing several shops and having bowling alleys on the second floor. The cause of the fire is unknown, but fire department re-

Savannah Evening Press.

Ruins of the Pastime Bowling Alley in Savannah, Georgia, following an early morning fire. Due to lack of automatic sprinkler or automatic fire alarm equipment, the flames had great headway before discovery, and although the entire Savannah Fire Department aided by their auxiliaries attacked the blaze, they were unable to prevent a major loss.

ports that the bowling alley had been operating until the previous midnight and that this may have had some bearing on the start of the fire. The fire spread to an adjoining tenement structure. Loss: $17,000.

May 22, 1944. Ben Doherty's Bowling Alleys, Woburn, Mass.

These bowling alleys, which have been a local institution for many years, were badly damaged by a fire starting in an outside rubbish pile at 7:00 P.M. The blaze first ignited a shed attached to the rear of the bowling alleys then spread to the roof of the structure. Firemen brought the blaze under control within 15 minuntes, but the alleys are said to have been ruined by water required to extinguish the fire. These alleys were housed in an old wooden structure. The damage was considerable.

May 30, 1944. Verona Bowling Academy, Verona, N. J.

Fire which had spread extensively before it was discovered at 5:20 P.M. destroyed this bowling alley property. The one-story building of concrete block and brick construction had been a former garage. The blaze apparently started in a storeroom and work room containing flammable liquids used for maintenance of the alleys. Fire spread upward between the suspended ceiling and roof and had extended through the roof before being discovered by a passer-by who operated a fire alarm box. The roof collapsed shortly after the fire department arrived. Firemen used 8 hose streams and aided by a fire wall were able to save the adjoining building. Loss: $65,000.

May 30, 1944. Pastime Bowling Alley, Savannah, Ga.

A fire of undetermined origin destroyed bowling alleys on the second floor of a two-story brick-joisted building. The fire was discovered by a policeman at 4:45 A.M. and at that time flames were bursting from the windows. The fire department responded to a general alarm and used 14 hose streams, including a stream from a ladder pipe to confine the fire to the building. The loss has not been reported, but represented a large portion of the value involved.

The Fire Hazard of Bowling Alleys.

Extracted from "The Fire Hazard of Bowling Alley Establishments," published by the National Board of Fire Underwriters.

As a rule most bowling alleys are located in basements or grade floors of multi-story buildings having miscellaneous office and other occupancies in upper stories. The exceptions are the modern establishments usually consisting of an excessive area 1-story building erected for this special type of recreation. The number of alleys varies widely. There is the church recreational hall or basement, usually with two alleys; the fraternal organization and private club, with from two to four or more alleys; and the commercial establishments, including the previously mentioned recreation building or center with alleys ranging in number from a few to a great many.

Most commercial alleys are provided with a bar or bar and grill. Sometimes only soft drinks are sold, but in many cases the establishment is combined with a tavern. In the case of the recreation center, the bowling alleys are supplemented by large billiard rooms.

As the alleys take up the major portion of the open space, the spectators' area back of the bowlers' end of the alley is usually restricted and frequently congested with players and watchers when the alleys are in general use.

In many cases a single entrance to the establishment is provided. Bowlers use this when entering or leaving the alleys. Other exit facilities are often inadequate and as a rule consist of a single door at the rear where the pin boys are located, or in one of the side walls. Thus it is plain that under fire conditions the possibility of panic is pronounced. Obviously these establishments should be treated as places of public assembly, with emergency exit facilities suited to the occupancy.

The management of some alleys claim that patronage has fallen off as the result of the war. On the other hand, alleys in or near industrial centers are in more or less constant use. This is due to the 24-hour operation of plants and the natural desire for recreation by the various shifts during the time they are off duty. This creates an operating problem that is made more difficult by the manpower shortage.

Common Hazards.

The hazards of electric lighting and heating appear to be generally well guarded in these establishments and there appears to be nothing in the fire record to indicate otherwise. It is plain, however, that the general care and cleanliness of premises has deteriorated as a result of the increased use of the alleys and the difficulty in securing labor. A hazard common to all such establishments is that of smoking by the pin boys. This is probably one of the most outstanding causes of fires in bowling alleys, as indicated by the fire record.

Special Hazards.

These are largely in connection with the maintenance of the surface of the alleys in good condition, and maintaining the pins so that they will set firmly and squarely on the alley and be clean and white so as to stand out and facilitate a proper aiming of the ball.

Prior to the war it was the practice to finish the surface of the alleys with white shellac, although pyroxylin lacquer has been used for ground coating purposes since 1930; owing to the war, while shellac is no longer available. Orange shellac appears to be available, but apparently this is not considered suitable because of its tendency to change color. As a result other materials are being used in place of shellac.

As a substitute for white shellac as a surface finish, pyroxylin lacquer is now being extensively used. Aside from its inherent fire hazard, this material has much to recommend it for this particular purpose. In the case of shellac the various coatings require a longer period for drying before an additional coat is applied; further a cross-section of the finished surface coating when carefully examined under the microscope clearly shows the number of coats or layers which have been applied. A finish of this type is not nearly so desirable as the pyroxylin finish, as the latter contains solvents and plasticizers which cause all successive coats to merge with those previously applied and thus in effect become a single solid coating; the pyroxy-

lin finish is not nearly so susceptible to cracking and will afford a longer life of service.

Proper maintenance requires that occasionally the surface finishing materials be completely removed so that the bare wood is exposed before resurfacing operations are started. Rules and regulations of the American Bowling Congress require that this be done at least every twelve months. This operation is usually conducted during the slack summer season, requiring complete shut-down. Although it is reported that with pyroxylin lacquer finish, annual complete removal is not necessary, because of its better wearing qualities, it is unlikely that any postponement of the annual resurfacing will result unless revised A. B. C. regulations are adopted.

When it becomes necessary to provide complete new surface finish, the old finish is removed by a sanding machine. In sanding off a finish composed of pyroxylin plastic, the residues produced are very hazardous, consisting of a high percentage of nitrocellulose, and should be wetted down, placed in an approved waste can, removed at frequent intervals, and disposed of by burying or by burning in the open at a safe location.

At frequent intervals between complete resurfacing jobs, a certain amount of refinishing or touch-up finishing is done, which usually involves the application of merely one coat of pyroxylin lacquer over the existing finish, after first thoroughly cleaning the surface, and perhaps minor sanding of rough spots. This secondary finishing should preferably be done when the establishment is closed, and the same precautions should be taken with respect to ventilation, etc., that are recommended for the regular resurfacing, but it is known that this operation is often conducted piecemeal, working on a few of the alleys at one time, while bowling is being carried on over adjacent alleys. Also, the majority of this touch-up work is done by regular employees of the bowling establishment, who are probably inexperienced in the safe handling of flammable finishes.

Ordinary cleaning of the finished surface is carried on at intervals, depending upon the extent to which the alleys are used. Under wartime conditions the heavy demand for these recreation facilities in many cases increases frequency of these operations. For this type of cleaning a solution largely of water, but also including soap flakes, silicate and paraffin oil is used. This removes the dirt and leaves the surface with a slight oil film. Cleaning operations are essentially non-hazardous.

Pyroxylin lacquers vary widely as to make-up and the character of solvents used. While the pyroxylin base is a material contributing factor to the inherent fire hazard, the nature of the solvent employed has much to do with the over-all hazard.

In making this investigation it was not feasible to secure samples of all of the pyroxylin lacquers used for finishing purposes in bowling alleys throughout the country. However, through the coöperation of one of the largest manufacturers of bowling alley equipment and supplies, generous samples of two of the pyroxylin lacquers used extensively for the resurfacing of alleys and coating of pins were received. Tests by Underwriters Laboratories, Inc., produced the following data concerning certain fire hazard properties of these lacquers:

Alley resurfacing lacquer: Flash point, closed cup tester, 20.3° F.; specific gravity at 60° F., 0.8657; ignition or decomposition temperature of residue, 334° F.

Pin refinishing lacquer: Flash point closed cup tester, 23° F.; specific gravity at 60° F., 0.8740; ignition or decomposition temperature of residue, 338° F.

The vapor density of the solvents used in these lacquers, with air equal to (1) in each case, so far as could be determined is considerably greater than air. This means that when the lacquers are applied, the vapors given off settle to the floor and will accumulate in low spots if adequate ventilation is not provided.

The fire hazard inherent to these lacquers would be appreciably less if the solvents and thinners employed in their manufacture and use were less volatile, so as to produce a higher flash point. In recognition of this fact the manufacturer above referred to has developed two new lacquers. Fact finding tests by Underwriters Laboratories, Inc., show that these new finishing materials possess the following properties:

Alley resurfacing lacquer: Flash point closed cup tester, 50° F.; specific gravity

at 60° F., 0.9140; ignition or decomposition temperature of residue, 346.3° F.

Pin refinishing lacquer: Flash point closed cup tester, 52.7° F.; specific gravity at 60° F., 0.9427; ignition or decomposition temperature of residue, 349.7° F.

The preparation of an alley for refinishing and the actual work of refinishing require skill, hence it is the practice of many concerns to have a competent outside concern to do this work. This is important, as it means entrusting the work to workmen who understand the hazards involved. Fire protection engineers and insurance authorities are well acquainted with the hazard of these lacquers and their extensive use is not a new development. If care is exercised and the handling, application and storage of the materials properly safeguarded, there is no reason why the use of these lacquers in the bowling alleys of the country should create any undue concern. As to whether the use of these materials has been the actual cause of any of the fires which have occurred during the past few years, it would seem that the answer can best be obtained by a study of the later paragraphs discussing the fire record of bowling alleys.

The refinishing of pins also involves certain inherent hazards. As previously pointed out, the wear and tear on the pins does two things, i.e., their bottoms become rounded on the edges, tending to make the pin rock and fall more readily, and the surfaces become dirty so that the pin materially loses its distinctness for aiming of the ball.

Some owners send their pins out to be finished by concerns specializing in this kind of work. This was found to be the case in many establishments located within the New York Metropolitan area, including the New Jersey suburbs, and also in the City of Chicago. Where this practice is followed, a definite hazard is removed from the bowling establishment. Where the work is done on the premises, a variety of conditions exist, ranging from good to poor. In some instances a small separate building is provided; in others the work is done in a separate, well-cut-off room, while in others a poorly located combustible room is used. When the latter condition obtains, a room located above and behind the pits is used. In such instances, ventilation is usually poor and access difficult, owing to distance of these rooms from exits or other openings which might facilitate fire department operations.

The active hazards in these pin refinishing rooms consist of dipping of the pins in or flow coating them with pyroxylin lacquer, and prior to that operation, the squaring off of pin bottoms on a wood sanding lathe. This combines the hazard of flammable vapors and woodworking. In this connection it is interesting to note that the use of pyroxylin lacquers for coating pins dates back to before the war. Indicated safeguards are standard cut-offs from other parts of the building in the case of rooms under the same roof; good ventilation; rigid adherence to a practice prohibiting the operation of the sanding machine while dipping or flow coating is in progress; grounding of the sanding machine, and storage of flammable liquids in a ventilated cabinet located outside of the building when safe inside storage facilities are not provided.

Carelessness on the part of pin boys with special reference to smoking has been demonstrated to be a definite hazard. The extent to which cigarettes and smoking in general are a fire cause in these establishments is indicated by the fire record.

The more pretentious of these establishments are provided with air conditioning systems. Inspections disclose that in some instances at least, these systems are not provided with the necessary means for preventing the spread of fire. Air conditioning makes for the comfort of the patrons, but if not properly installed with reference to fire prevention it creates a definite hazard. As an illustration of such weaknesses, one case was noted where the lack of dampers at a division wall permitted the spread of fire to an adjoining section. Similar defects were found in other alleys.

A hazardous feature noted in most establishments recently inspected is the quantity of flammable liquids kept on hand and the method of storage. These liquids consisted of pyroxylin lacquers, thinners and shellac. Original containers, usually 5-gallon cans with location under a counter or in a closet appear to be the most usual location and method of storage.

No special oil storage rooms or outside storage cabinets were observed.

The quantity of pins usually found stored is also worthy of comment. When it is realized that a special set of pins is kept for the use of each league, and there may be two or three leagues playing per day on five or six days a weeks, it is apparent that the number of sets of pins kept in storage may run as high as 20 to 25 sets per alley, in addition to all the off-standard pins which are used during hours of "open" play. Frequently these are found in storage in the concealed attic space above the alleys, particularly at the end above the pits; they may be kept in wooden or cardboard cartons or in special bins, and in the aggregate they constitute a far greater quantity of combustible storage than is generally believed to be present in properties of this kind.

Conclusions.

It is plain that the frequency of fires has materially increased during the years the country has been at war. Increased demands for recreational services, but with a character and supply of help greatly below the normal, have brought about a need for safer maintenance operations and greater care and vigilance with respect to good housekeeping.

A study of the larger fires which have occurred clearly indicates that structural weaknesses from the fire prevention standpoint, such as extensive concealed air spaces formed by suspended ceilings of combustible construction, have facilitated the spread of flames and made fires of such extent possible.

It is true that the use of pyroxylin lacquers for the resurfacing of alleys and dipping of pins creates a somewhat greater potential hazard, as illustrated by the recorded fires in which the ignition of their vapors contributed to the spread of fire, but in this respect the situation is not any different than it was many years ago when such quick drying lacquers were first introduced in the automobile and finishing industries. It was found then and it is also true in the present instance, that the hazard of these finishing materials only becomes active when the conditions surrounding their application are not properly controlled. A study of the fire causes is definite proof of this—inadequate ventilation and the presence of sources of ignition. A comparison of the fire hazard characteristics of the quick drying lacquers, with special reference to flash point and vapor density with shellac, gives no reason to justify any belief that a more dangerous finishing material is the reason for this greater fire frequency. Investigation also discloses that pyroxylin lacquers were used for these purposes in bowling alleys as early as 1930. The only difference at present is the greater extent to which they are so used.

When considered in connection with the type of help that must be utilized in these establishments, it is plain that control of the smoking hazard, which incidentally stands out as the most prominent cause of fires in bowling alleys, will prove difficult. Most of the trouble appears to originate in the pin rooms where the pins are reconditioned. As this work is usually done when the alleys are closed and supervision is absent, the enforcement of no-smoking will not be an easy matter. For this reason the operators of bowling alleys should be encouraged to have the work done by outside concerns off the premises, as is now being done by an increasing number of bowling alley proprietors in various parts of the country. The refinishing of alleys should also be intrusted to outside concerns specializing in this work. When any or all of such alley refinishing or pin reconditioning operations are done on the premises the following recommendations should be complied with.

Attention is also directed to the inadequate exit facilities and poor means of access for fire department operations usually found at these establishments. A proper understanding of the character and extent of these hazards and a full realization of their responsibility to the public, on the part of alley proprietors, is the most effective way to secure safe operation of these establishments.

Recommendations.

1. (a) The most effective way to remove the hazards inherent to bowling pin refinishing operations is by having this work done off the premises by a concern specializing in this kind of work. This practice is therefore recommended.

(b) When for any reason compliance with the foregoing recommendation is not feasible,

bowling pin refinishing operations should preferably be carried on in a separate, small building provided for this purpose and wherein the principal safeguards such as required for an inside refinishing room and as described under the following recommendation (c) are provided.

(c) If such bowling pin refinishing operations are carried on in a room located in the same building with the bowling alleys the following specifications should be complied with:

(1) Such rooms should preferably be located on the first floor of building and under no circumstances in the cellar or basement. Location of the room in a corner of the building, or if this is not feasible, at least so as to have one side of the room formed by an outside building wall having one or more windows is recommended.

(2) Walls should be one of the following types of construction: be continuous from floor to ceiling, and be securely anchored.

Metal lath encased in solid cement plaster not less than 2½ inches thick.

Gypsum or cement plaster at least ¾-inch thick on metal lath on each side of wood stud partitions.

Tile, gypsum or concrete block (cement plaster on each side to a thickness of ¼ inch).

In lieu of the foregoing, any type of partition which will afford one hour's protection against fire as determined by the American Society for Testing Materials' Standard Fire Test Specifications.*

(3) Ceiling should be of construction equal to not less than ¾ inch of cement or gypsum plaster on metal lath.

(4) Floor if of wood should be protected with not less than 2 inches of concrete or equivalent material. If situated over damageable materials, floor should be waterproofed and provision made for drainage to a safe place.

(5) Door openings to other rooms or building should be provided with non-combustible sills raised 6 inches. Such openings should be protected by standard Class C fire doors of approved automatic or self-closing type.

(6) Where other portions of the building or other properties are exposed, windows should be protected in a standard manner.

(7) Shelving should be non-combustible.

(8) Artificial lighting and power should be by electricity with installation and equipment in accordance with Article 500 of the National Electrical Code, for Class 1, Group D hazardous locations.

(9) Ventilation of capacity sufficient to effect a complete change of air in the room at least once in every three minutes is necessary for operations of this type involving such flammable vapors. Such ventilation is recommended and may be by natural or mechanical means. When a mechanical system of ventilation is required, the installation should be in compliance with the requirements for the removal of flammable vapors, as provided by the Standards for the Installation of Blower and Exhaust Systems.*

(10) An approved waste can should be provided for the storage of oily rags or waste; contents should be removed daily.

(11) Heating should be restricted to low pressure steam or hot water supplied from an outside source.

(12) When the foregoing specifications for inside bowling pin refinishing rooms are complied with, such rooms may be used for the storage of volatile flammable liquids, as well as their application. It is recommended, however, that not more than 60 gallons be kept on hand, and then only when stored in metal original containers, or approved safety containers not exceeding 5 gallons individual capacity.

(13) If pins are refinished by dipping, an approved dip tank should be provided. If by hand brushing or flow coating the operation should be over a metal protected section of the floor. Regardless of refinishing method employed, the installation and use of the equipment attendant thereto should be in accord with those standards which may apply.†

The thorough cleaning of dip tank and space used for brushing operations upon completion of such work is a cardinal need for the prevention of fires.

(14) If provision is made for buffing and sanding pins, and lathes, sanding machines, etc., for use in that connection are provided, great care should be exercised to insure that no other operations involving the use of lacquers or other flammable finishing materials are permitted while such buffing or sanding is being carried on. Employees should be carefully instructed to this effect, and signs of caution should be prominently posted in the room.

(15) Lathes and sanding or buffing machines should be effectively grounded. Such machines should be arranged to discharge dust into a substantial metal dust box or other approved receptacle as provided by section 470 of the Standards for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal.*

(16) The importance of preventing smoking or carrying matches in the bowling pin refinishing room cannot be overemphasized. As shown by the fire record, smoking is directly or indirectly the most outstanding cause of fire in bowling establishments. Unless this practice can be controlled, practically all of the other

†See National Fire Codes for Flammable Liquids, Gases, Chemicals and Explosives.
*See National Fire Codes for Building Construction and Equipment.

safeguards here recommended will be largely useless and futile. It is accordingly urged that the management of every establishment rigidly enforce such a prohibition and that violation of this rule be punished by instant discharge.

(17) For first aid fire protection there should be provided extinguishing equipment of such type and amount as required by the Standards for First Aid Fire Appliances** for Class B fires. Such rooms may also require protection by automatic sprinklers or other approved means.

2. (a) It is urged that bowling alley resurfacing or refinishing operations and all cleaning operations involving the use of flammable solvents be entrusted to an outside concern specializing in this kind of work.

(b) If necessarily done by employees of the bowling establishment, they should be thoroughly informed of the hazards of the refinishing materials employed and the safeguards to be provided.

(c) Such refinishing operations should never be carried on while any portion of the establishment is in operation or open for business. All fires, open flames or other sources of ignition should be extinguished or removed before operations are started.

(d) While such operations are being carried on and for some time thereafter the area in which the alleys are located should be thoroughly ventilated. During these operations the air conditioning system should be shut off.

(e) While such operations are under way there should be readily available for use in emergency an adequate number of fire extinguishers suitable for use on Class B fires.**

3. General care and cleanliness, or in brief good housekeeping, is another essential to the prevention of fires. To this end all combustible waste materials and rubbish of all kinds should be collected and deposited in approved waste cans, and the contents safely disposed of at the close of each day.

Lacquer residue from sanding machines should be wetted down, placed in an approved waste can and safely disposed of.

4. The development of higher flash point lacquers such as referred to in the preceding text should be encouraged and every effort made to make them available in the near future.

5. As pointed out in the preceding text, inadequate exit facilities are common to these establishments. As a rule the exits are almost entirely at one end of the area containing the alleys, with none on the sides or at the end where the pin boys are located. It should be borne in mind that the bowling alley is a place of public assembly, hence safety of the patrons and protection against panic is a responsibility of the management. The emergency exit requirements of each establishment should be separately determined and additional exits provided where needed. In general this will require exits in sidewalls and at the end of the alleys.*

In numerous cases such additional exits are also necessary in order to provide the fire department with suitable access in case of fire.

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*See National Fire Codes for Building Construction and Equipment.

**See National Fire Codes for Extinguishing and Alarm Equipment.

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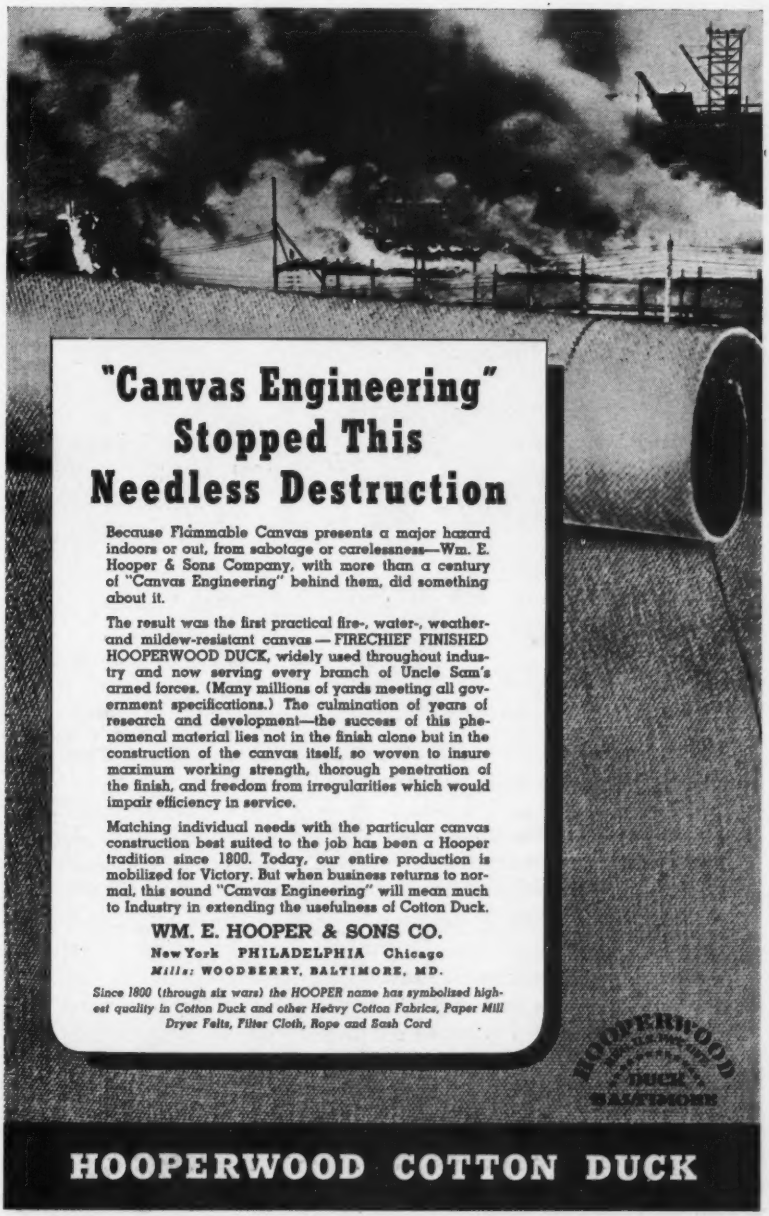
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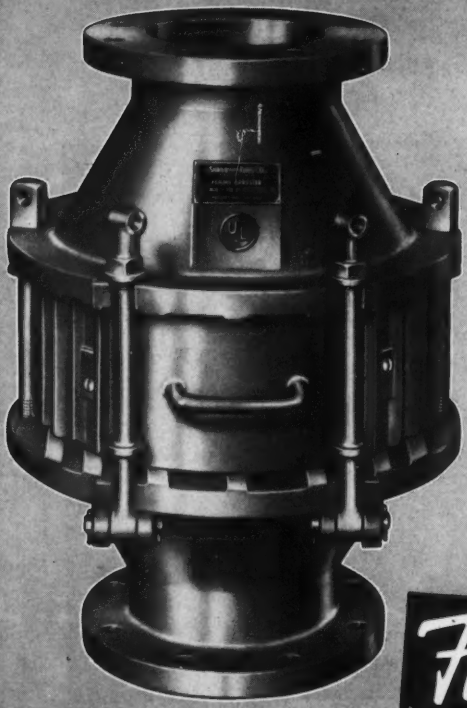

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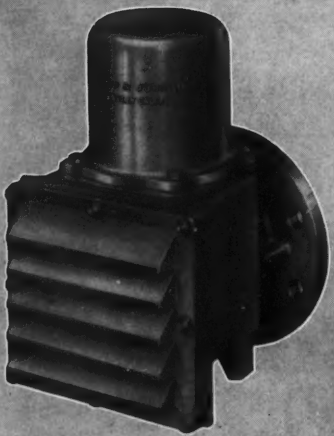

FIGURE 87-4165

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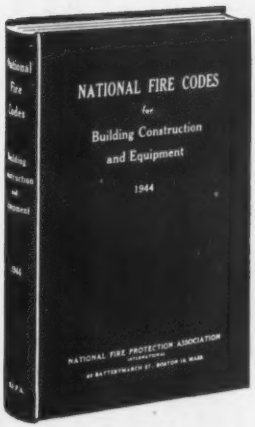

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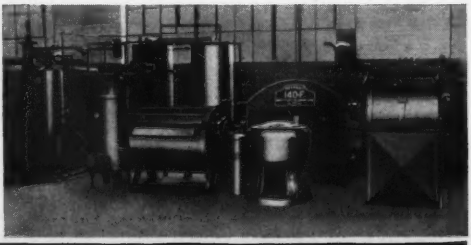

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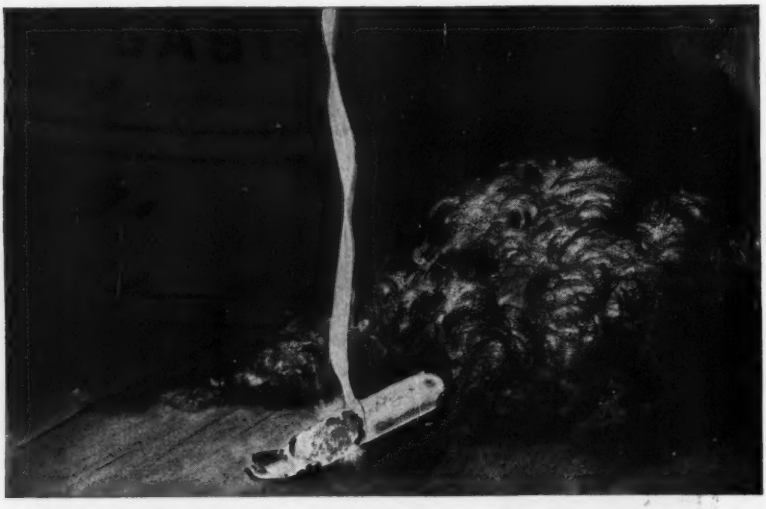

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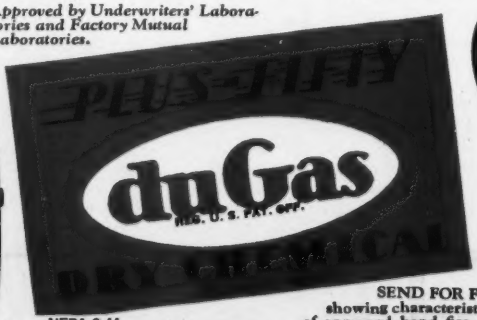

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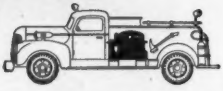
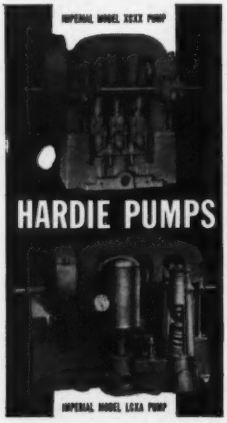
for Best Results from Fog Fire Fighter

Above is shown Great Fog Fire Fighting truck built by General Fire Truck Corporation, Detroit, Mich., for U. S. Army Engineers. Equipped with a Hardie Imperial LCX pump delivering 60 gallons per minute at 800 P.S.I. at the slow speed of 130 RPM.





● Constant, sustained high pressure, to overcome all hose friction loss and deliver ample pressure at the nozzle to produce complete and perfect atomization of the water—that is the principle of Fog Fire Fighting which makes the pump such an important part of the Fog Fire Fighter.

For over 40 years Hardie has specialized in the manufacture of vertical crankshaft-driven pumps that have proven their quality in all the fields where such pumps are used. Hardie design and extra strong construction are supplemented by complete lubrication—every moving part, including plungers and plunger cups, runs in a bath of oil. These exclusive design and construction features make a Hardie pump the choice of outstanding builders of Fog Fire Fighters. Made only by The Hardie Mfg. Company, Hudson, Mich., Los Angeles, Calif., Portland, Ore.

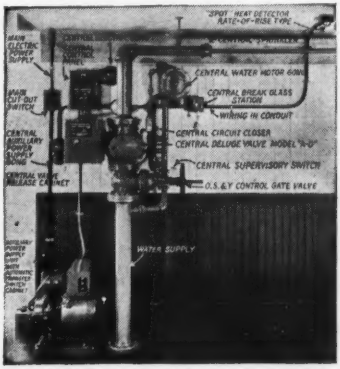
● Single Trigger Control is a feature of the Hardie Fog Fire Gun. Pressure of the fingers on the easy-acting trigger opens the gun and selects the type of stream desired from wide close-up drenching fog spray to long distance stream. The gun closes instantly when pressure on the trigger is released. Strongly built to deliver nozzle pressure of 500 to 1000 P.S.I.

Perfected Fog Fire Gun

★H★A★R★D★I★E
High Pressure PUMPS AND FOG GUNS for Fog Fire Fighters

There is always the One Best

Central "Electro-Speed" Deluge Sprinkler System Model "AD"



Completely Electrically Operated

• • •

Rate of Rise and Fixed Temperature Controlled

• • •

Fully Supervised

"A PRODUCT OF THE ELECTRONIC AGE"

Over three years ago we pioneered the first Underwriters approved electrically operated deluge type automatic sprinkler system. We now present, in the CENTRAL Model "AD" Electro-Speed Sprinkler System, a completely new and all electrically operated system, amazing in its simplicity of design and in its instantaneous super-speed electric operation.

Every functional part is a standard product with years of dependable use to insure for you satisfactory and continued service.

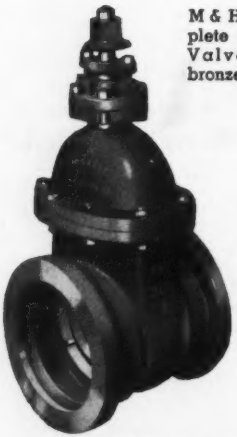
Approximately two hundred CENTRAL Model "AD" Deluge Sprinkler Systems are now in service protecting vital United States Army and Navy, and privately owned properties, and proving their superior design and operation over older types of deluge systems in adjacent buildings in some of these properties.

Send for illustrated and descriptive bulletin N.P.-V-4.

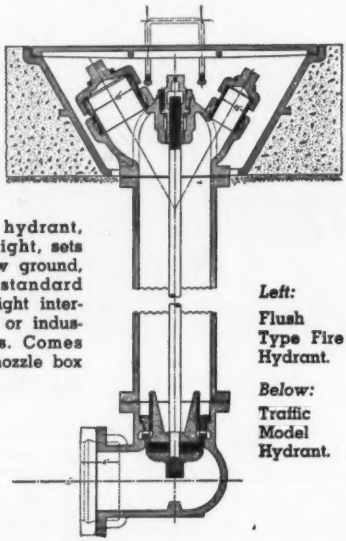
CENTRAL AUTOMATIC SPRINKLER CO.

241 EAST ASHMEAD STREET . . PHILADELPHIA, PA.

VALVES
HYDRANTS
AND PIPE LINE ACCESSORIES



M & H furnishes a complete line of AWWA Valves, iron body, bronze mounted.



Flush type fire hydrant, illustrated at right, sets completely below ground, is used where standard type hydrant might interfere with traffic or industrial operations. Comes with cast iron nozzle box and cover.

Left: Flush Type Fire Hydrant.

Below: Traffic Model Hydrant.

AWWA & UNDERWRITERS APPROVED FIRE HYDRANTS

M & H Fire Hydrants are dry top and revolving head. They are easy to lubricate. Maintenance costs are low due to simplicity of design and rugged construction. They have low friction loss and great efficiency because barrel diameter is not reduced and there are no working parts or obstruction in waterway. Special Traffic model is designed to yield at the ground line under impact. Repair is simple and easy.

M&H VALVE
AND FITTINGS COMPANY
ANNISTON, ALABAMA

FREE BOOK helps keep extinguishers ready for action

You'll be prepared to nip fires quickly at your plant only if your *extinguishers* are ready. And that calls for periodic examination.

To make it easy for you to set up a maintenance system, Walter Kidde & Company has issued a booklet—"INSPECTION AND MAINTENANCE OF FIRST AID FIRE EXTINGUISHERS." It covers every type of equipment, tells where to locate them, how to mark them for quick identification, what to check, how and when to recharge. It suggests forms for keeping records. Write for your free copy today!

WALTER KIDDE & COMPANY, INC., 140 CEDAR STREET, NEW YORK 6, N. Y.

like having a

FIRE DEPARTMENT

IN YOUR OWN PLANT

INDUSTRIAL SPRINKLER SYSTEMS

Viking Sprinkler Systems go into action with the speed of a Fire Department in your own plant. In peace and war Viking Sprinkler Systems are protecting industrial plants across the nation against the universal enemy of production . . . . FIRE. There is a Viking dealer near you to give you all the facts.

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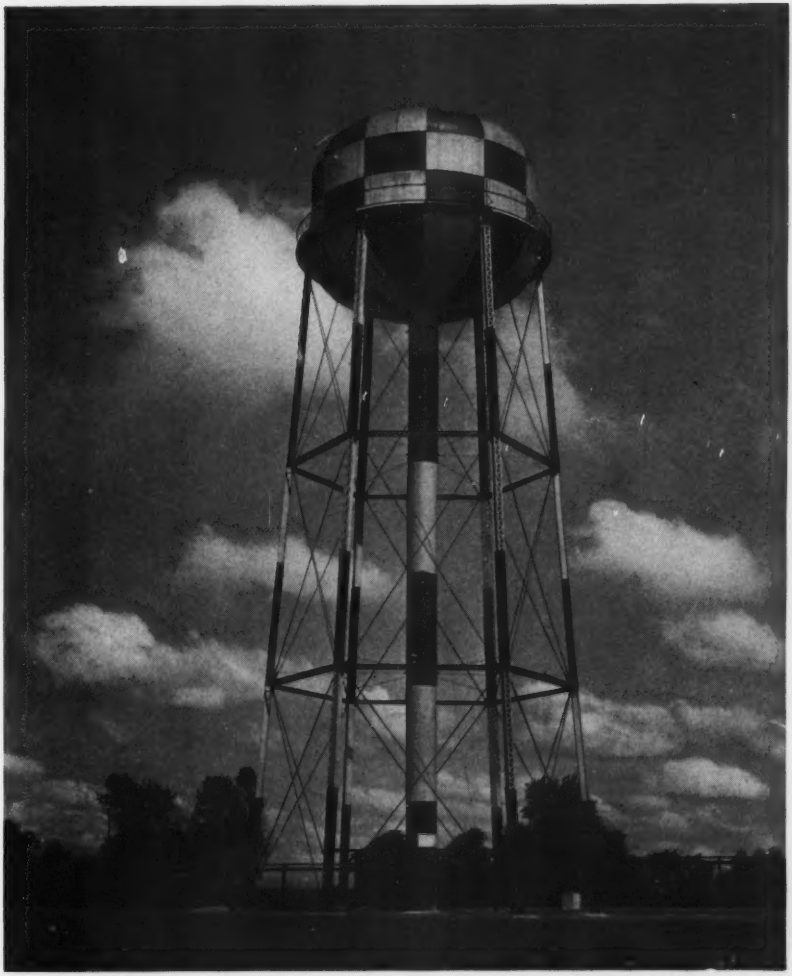

Real Protection for Hazardous Areas

This 200,000-gal. Horton elevated tank provides gravity water pressure for fire protection in the fuse and booster area at an ordnance plant in Ohio. It stands ready, night or day, whenever fire threatens. Write our nearest office for information or quotations.

CHICAGO BRIDGE & IRON COMPANY

CLEVELAND CHICAGO BIRMINGHAM NEW YORK
WASHINGTON HAVANA GREENVILLE, PA. PHILADELPHIA
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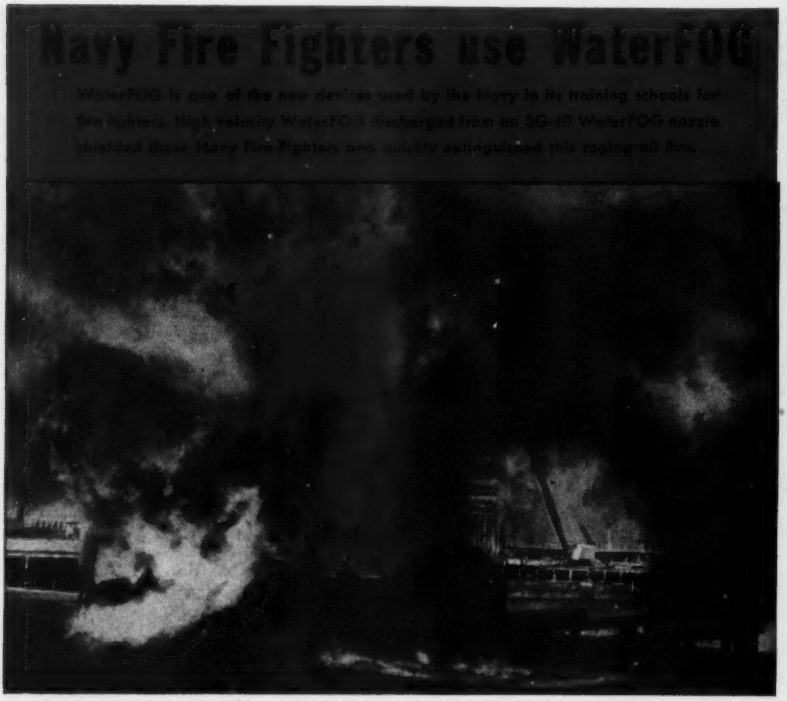

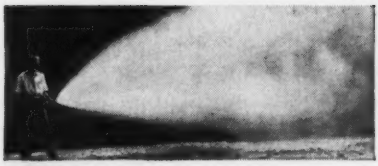

High velocity WaterFOG from an approved SG-40 nozzle designed for the U. S. Navy by Rockwood Sprinkler Company.

★

Hundreds of industrial plants also have WaterFOG equipment, — both fixed piping installations and nozzles for hose lines.

What Is WaterFOG?

WaterFOG is man-made fog, created by impinging streams of water from specially-designed Rockwood nozzles. It is particularly effective on oil fires, because of its great heat-absorbing area (much greater than in solid stream or spray) and its floating action.

Instead of plunging quickly through the flame into the liquid, thus increasing vaporization — WaterFOG drifts gently into the combustion area, cooling both the burning vapors and the liquid surface, and then changing into steam, cuts off oxygen supply.

Many firms have given up more expensive, less certain fire-fighting methods to return to water. WaterFOG, economical, plentiful, prevents "flashback," saves costly chemicals, lessens water damage and is a non-conductor. Rockwood installations are approved by Underwriters' Laboratories and Factory Mutuals. Write for bulletin 123.

ROCKWOOD SPRINKLER COMPANY

56 Harlow St., Worcester 5, Mass.

Specialists in Fire Protection Engineering, Equipment and Installation since 1907

ROCKWOOD WaterFOG

WATER, ENGINEERED BY ROCKWOOD, COOLS, CONFINES, SMOTHERS OIL FIRES

WHERE IS THE NEAREST FIRE ALARM BOX?

for FIRE USE THE NEAREST BOX NO.
AT
and wait for the Firemen
DO YOU KNOW THAT
600,000
fires occur annually in the U.S.A.
10,000
human lives are lost and
100,000
others are seriously injured and
$400,000,000
in property values plus the indirect losses creating a total waste in excess of One Billion dollars are annually destroyed by Fire.
70%
of the fires — and life losses occur in dwellings.
43%
of the commercial establishments destroyed do not rebuild, and the community loses prestige, business, payrolls, taxes and wealth.
50
times its original size is the spread of fire within 8 minutes after inception.
WHEN FIRE OCCURS—
Use the Box IMMEDIATELY
Delayed Alarms are largely responsible for the excessive Fire Loss.
The Box Is Your Best Protection
FIRE DEPARTMENT

INSTRUCTION CARDS

PROMINENTLY DISPLAYED

in every building will inspire "fire consciousness" and proper action when fire occurs. Fire signaling facilities were never more urgently needed, but scarcity of materials necessitates greater dependence upon existing boxes. Their prompt use for fire will conserve national resources.

THE GAMEWELL COMPANY

NEWTON UPPER FALLS, MASSACHUSETTS

GRINNELL
MULTITROL SYSTEMS

FOUR-WAY PROTECTION AGAINST FIRE

• • •

Grinnell MULTITROL Sprinkler Systems afford an answer to the demand of those who require sprinkler protection with the added advantage of speedy-action fire detection. Its features may be summarized as follows:

DETECTION

A Grinnell MULTITROL System detects fire quickly. Even a small blaze gives off sufficient heat, within a matter of seconds, to set the system in operation, and bring into play its fire protection devices.

WARNING

Once fire is detected, the Grinnell MULTITROL System sounds an alarm warning of the danger. With the closed head system, this warning may occur in advance of sprinkler action, especially if the fire is slow in starting.

CONTROL

The action of the Grinnell MULTITROL System does not stop with detection, warning and sprinkler protection. Mechanical devices that guard against fire may also be set in operation without the touch of a human hand, by this system.

SUPERVISION

In addition to rapid detection and fire protection, a Grinnell MULTITROL System keeps constant, unfailing vigil over itself. Should any part of the system be damaged or tampered with, a special "trouble alarm" lets go with an unmistakable cry for help.

Descriptive literature is available for the asking from any of our offices throughout the country. Grinnell Company, Inc., Providence 1, Rhode Island.

GRINNELL

AUTOMATIC SPRINKLER FIRE PROTECTION